SAE Journal

MAY 1958

IN THIS ISSUE . . .

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SAE journal

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SAE journal

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The SAE Story for May

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To order complete papers on which articles are based, turn to page 5.

SAE JOURNAL, May, 1958, Vol. 66, No. 5. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50¢ per number, $5 per year. Entered as second class matter, Sept. 15, 1948, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of Feb. 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y.

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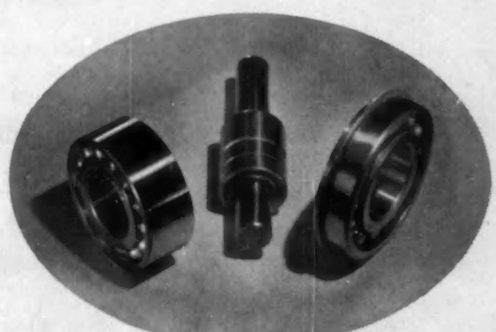

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AIRCRAFT

Economic Comparisons of Helicopter and Surface Transportation for Company Executive Use, W. H. MADSON, L. H. SLOAN. Paper No. 6A presented Jan. 1958, 13 p. Economical advantages of executive helicopter capable of carrying 10 passengers and 1000 lbs of cargo up to 100 mi at block speeds; comparison of operating costs with those of other transportation means; evaluation of hypothetical complex route; dollar savings due to helicopter transport and other benefits.

"What Price Pay Loads", G. B. EASTBURN. Paper No. 6B presented Jan. 1958, 10 p. Economic value of transportation vehicle is net lift available when passengers are to be boarded and cargo unloaded; New York Airways' planning is centered around adequate payload as essential design requirement in development of helicopter; operating experience with Sikorsky S-55 and S-58; it is shown that in near future scheduled transportation can be conducted on self sustaining business basis.

Opportunity for Competitive Advantage Between Jet Transport Operators, M. WHITLOCK. Paper No. 8A presented Jan. 1958, 10 p. Consideration of physical assets offering greatest contribution to improved service in jet transportation; facilities that must be provided to service aircrafts and minimum requirement for conventional taxi in and taxi out of jet aircraft; it is concluded that taxi straight-in, second level loading, push out with tractor and turn, unhook and taxi away represents arrangement having best competitive advantage.

Two Methods of Aircraft Skid Control, G. H. COLLIER. Paper No. 8B presented Jan. 1958, 10 p. Basic difference of systems is that in Skid Warning brakes are controlled by pilot, while Automatic Anti-Skid releases brake pressure automatically by means of hydraulic valve; with either system, d-c generator, driven by wheel, senses changes in wheel rotation; by connecting generator through electrical circuitry, deviation of wheel from normal deceleration is sensed; sequence of operations; detailed circuitry of systems using some sensing, power, and locked wheel prevention circuits.

Potential Application of Niobium to Aviation Gas Turbines, W. S. HAZELTON. Paper No. 14A presented Jan. 1958, 14 p. Properties of niobium making it attractive for high temperature service; strength and ductility, oxidation resistance, ease of fabrication, and cost and supply of niobium; how it compares with molybdenum.

Manufacture of Titanium Jet Engine Parts at Lower Costs by Extrusion, N. J. FEOLA. Paper No. 14B presented Jan. 1958, 10 p. Information on overall manufacturing method and individual operations in production of annular rings in unalloyed titanium and 5% Al-2.5% Sn titanium alloy at Curtiss-Wright Corp; extrusion processing variables; mechanical properties in extruded sections; forming of extruded shapes into 360° rings; flash butt welding and sizing; money savings and other advantages of extrusion method.

Method of Evaluating Tolerable Bearing Misalignment, R. S. LANGDON. Paper No. 17C presented Jan. 1958, 8 p. Analysis of nature and causes of misalignment in aircraft motor bearings; misalignment of outer groove due to axial or radial runout, and of inner groove due to axial runout or to eccentricities; both types of misalignment given with respect to true shaft center line about which shaft rotates; factors to consider in design-

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SAE Papers Available

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Briefs of SAE PAPERS

Continued from page 5

ing experiment to evaluate statistical relationship between misalignment and bearing life.

Discussion of Behavior of Bearings Made of High Temperature Materials, A. S. IRWIN. Paper No. 17D presented Jan. 1958, 3 p. Reference made to antifriction bearings manufactured of SAE 52100 steel types; lack of metallurgical tool for adequate selection of best high temperature materials noted; progressive tests now in use for screening these materials; difficulties in selection of materials for high temperature antifriction bearings to operate in high temperature lubricants.

Effect of Loading Systems and Vibration on Bearing Life, C. L. DELLINGER. Paper No. 17E presented Jan. 1958, 4 p. Discussion of five areas or systems which produce loads and/or vibration that could adversely affect bearing life, including gears, armature, stators, external vibration and external forces.

Possibilities in Field of Dry Lubricants, R. L. JOHNSON. Paper No. 18B presented Jan. 1958, 10 p. Research information on solid lubricants compiled for consideration of possible use of such materials in aircraft electrical equipment; theory of solid film lubrication; potential solid lubricants; methods of using them.

Mechanical Factors Involved in Bearing Design for Aircraft Electric Motors, T. W. BAKEWELL. Paper No. 18D presented Jan. 1958, 6 p. Design problems discussed are how to obtain minimum wear within bearing without severely reducing capacity, and how to design for minimum effects of wear; illustrated examples of design aspects; selection of bearing materials.

Jet Transport Operation — Nationally, R. D. KELLY. Paper No. S46 presented Nov. 1957, (Southern Calif. Sec.) 8 p. Successful application of jet craft to domestic operations depends upon many factors other than technical perfection of equipment; advantages of "block-to-block" jet flight times are off-set by amount of time for ground activities in which passenger is involved; need for modernization of airports, ground transportation systems and adequate runways for jet aircrafts.

Management's Role in Meeting Future of Aircraft Industry, E. STONE. Paper No. S49 presented Feb. 1958, (Metropolitan Sec) 13 p. Management's role in industry in general and problems peculiar to aircraft industry; requirements of Defense Department; curtailment of availability of defense funds; missile activities in research and development stage, and problems involved; decisions to be taken now which will affect companies, their employees and industry in general.

FUELS & LUBRICANTS

Multigrade Oil for Fleet Use, L. J. TEST, R. E. GREEGER. Paper No. 243 presented Nov. 1957, 12 p. Advantages gained for passenger cars and light truck through use of multigrade oils having high viscosity index; use of polymeric additives; requirements of heavy duty multigrade oil; advantages of its use for fleet operations with particular reference to multigrade oil 20 W-40; results of service experience in fleets.

Engine Tests for Military Lubricants, H. F. KING, L. G. SCHNEIDER. Paper No. 250 presented Nov. 1957, 15 p. Philosophy and background data underlying development and application of Navy diesel engine lubricating oil specifications; reasons for changes in test procedures on basis of engine performance; results of tests undertaken to detemine effect of requirement that all oils be qualified with max sulphur content fuel of 1%; evaluation of five oils used in GM 71 and Caterpillar 1A engines.

Effect of Hydrocarbon Type and Distribution in Boiling Range on Road Antiknock Performance, W. A. P.

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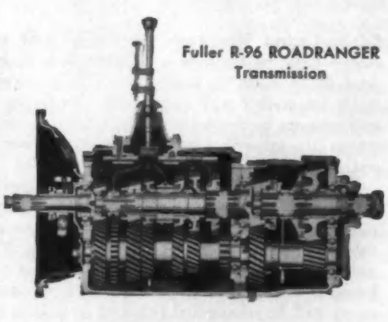

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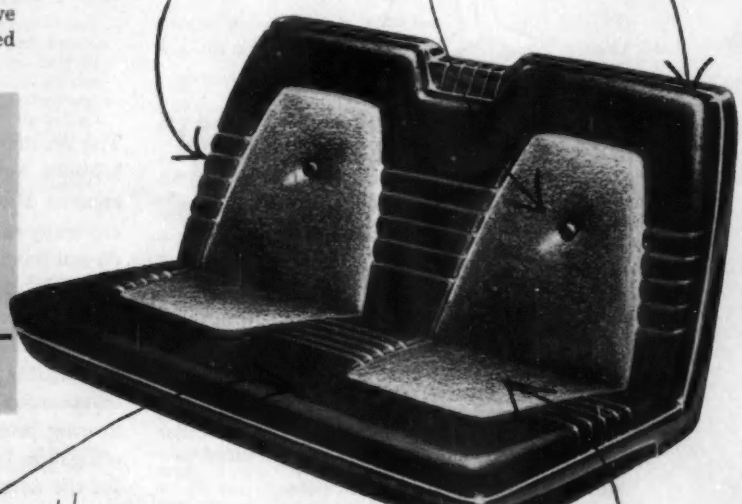

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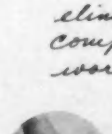

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2. At top of first page of each entry must appear contestant's name, home address and phone number; company name, address, phone number.

3. In preparing your entry use **only one side** of sheet or sheets.

4. Contestant may enter as many different types of Ermeto applications as he wishes but each must be a separate finished manuscript in itself.

5. Contest ends September 30, 1958 and entries must be postmarked no later than midnight of that date. Winners will be announced as soon thereafter as judging can be completed. In case of a tie, duplicate awards will be made.

6. Judging the contest will be qualified graduate engineers of high standing and not associated with Weatherhead Company or its sales outlets. Their decisions will be final.

7. All entries must be based on actual installations backed by factual data which can be fully verified.

8. All entries become the property of the Weatherhead Company.

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TO HELP YOU PREPARE A WINNING ENTRY

1. Your entry will be judged on the basis of how fully it covers all the facts relative to the installation you are describing. It should point up how or why Weatherhead flareless Ermeto tube fittings helped master a problem or achieve greater economy.

2. Drawings of the installation and pictures should accompany your manuscript if at all possible.

3. Unusual applications, excessive pressures or heat conditions, problems of surge or vibration, all are important data for your manuscript.

4. The following is offered as a guide to you in completing your manuscript . . . Type of equipment and its end product or function • Specific supporting function of the Ermeto equipped circuit • Location of equipment • Climatic conditions of equipment area • Restricting factors surrounding equipment • Downtime and maintenance factors • Style and material of Ermeto fittings and number in circuit • Material of connecting tubings • Working pressures • Maximum shock or impulse load • Maximum and minimum working temperatures of circuit • Vibration-maximum deflection factors • Type of hydraulic fluid used • Thickness of tube walls • To what piping specifications does circuit conform • Service life of Ermeto fittings being used • Savings or other economy factors resulting from use of Ermeto fittings.

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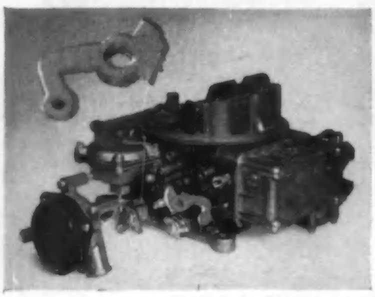
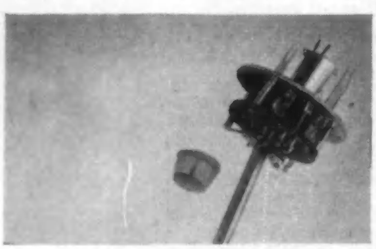
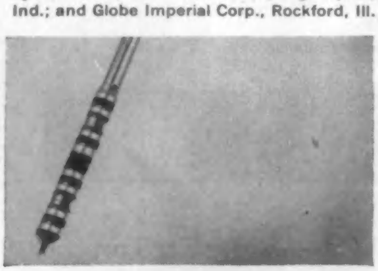
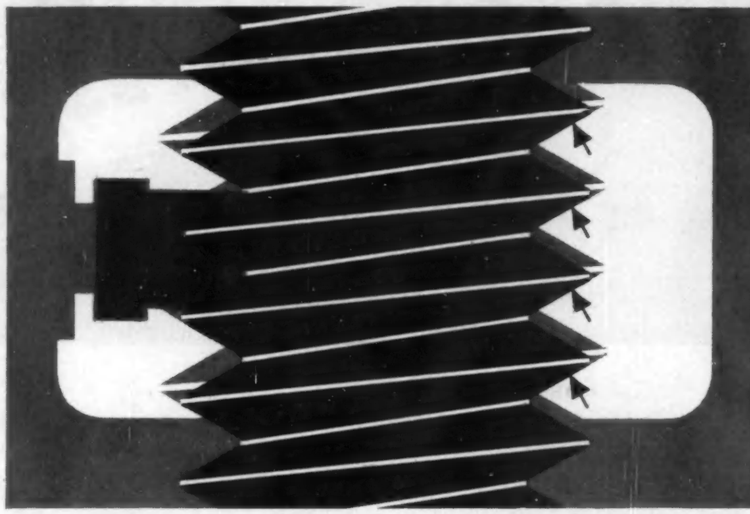


FAST IDLE CAM of the carburetors used on the new EDSEL is made of a ZYTEL nylon resin. Replacing metal, the molded cam eliminates 3 finishing operations and saves over 50% in production costs. The resin is unaffected by engine compartment heat. Strength and abrasion resistance of the part provides long operating life. (Part molded by Chicago Molded Products Corp., Chicago, Ill. for Holley Carburetor Co., Warren, Michigan.)



INSULATORS and switch parts at the top of the EDSEL steering shaft and collector rings at the bottom depend on good dielectric strength of ZYTEL resins. Tapered bushing used on shaft has excellent bearing properties and wear resistance. These EDSEL parts are supplied to Ainsworth Precision Castings Co., Division of Harsco Corp., Detroit, Michigan; by RBM Div., Essex Wire Corp., Logansport, Ind.; and Globe Imperial Corp., Rockford, Ill.





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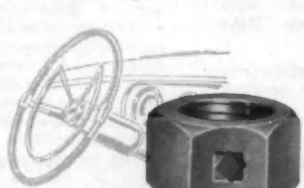

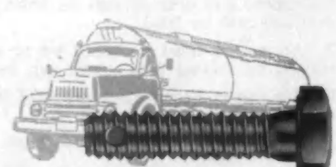

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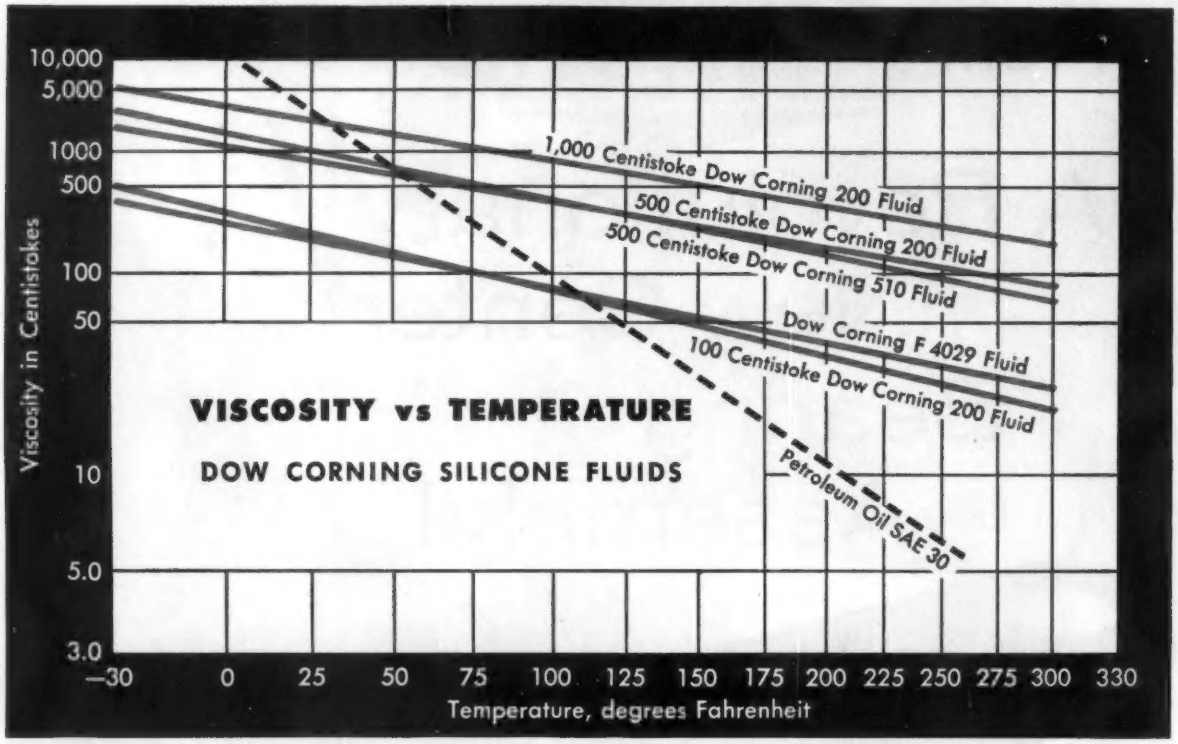

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For The Sake of Argument

Rhetorical Questions . . .

By Norman G. Shidle

The rhetorical question ranks high in the scale of man's fruitless activities. Some are more addicted than ,others to this particular combination of cliche and futility, but few are in a position to cast stones.

"What's the world coming to?" "How can anybody be so (dumb) (stupid) (selfish) (thoughtless) (unfair)?" "What *is* the matter with this younger generation?" . . .

All of these and hundreds of their mates, each of us has heard and asked. Grownups ask rhetorical questions about children . . . teenagers ask questions about grownups. Neither expect — nor really want — responses from anyone except themselves.

Usually, rhetorical questions forecast a statement of conclusions at which we have long ago arrived. They lead to compounding the error of worrying about things that cannot be changed or corrected — and the mistake of trying to compel other persons to believe and live as we do.

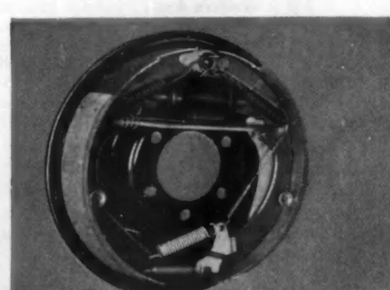
To listeners, a rhetorical question signals a declaration, not an exploration; a proclamation rather than a suggestion; an invitation to argument, rather than discussion.

For all their interrogatory form, we usually ask rhetorical questions in a tone which says:

> "Only at your own risk shall you dare to give any response except the one which I am convinced is axiomatic."

Rhetorical questions are first-cousins to those other futile phrases so common in conversational gambits — "If people only would (do this or refrain from doing that); "If only everybody would . . . "; "There ought to be a law . . ."

More fruitful is the thinking which reacts with an automatic: "Well, what's my own next best step?"



When shoe clearance exceeds a predetermined amount, a ratchet sets up the star wheel adjuster one notch as the brakes are applied while the car is in reverse. This automatically compensates for lining wear, adjusting the shoes to exactly the right fit within the drum.

chips

from SAE meetings, members, and committees

AIR FORCE UNDER-SECRETARY Malcolm A. MacIntyre made "a public admission of a private hope" . . . when he estimated that the first lunar probe would occur "in a matter of months." His "admission" was made at a press conference held last month during SAE's National Aeronautic Meeting in New York. (See meeting story starting on page 89.)

•

An engineer is a scientist who knows the value of a dollar.

•

JP-4 TYPE hydrocarbon fuels or boron fuels or a fuel combining both will power the supersonic transport of 1975, is the indication of SAE's Aircraft Activity Committee.

The transport will be inherently capable of vertical take-off and landing, the majority believes.

Before the supersonic transport can become a reality, however, further development will be needed in:

- Air traffic control systems (including proximity warning devices or automatic collision avoidance systems, and automatic landing devices, and speed and course control).
- High-lift devices (such as boundary layer control, jet flaps, drag reduction configurations).
- Noise suppression (for both engine noise and the supersonic plane's continuous traveling supersonic boom.
- Reliable non-afterburning powerplants with good fuel economy.

PROPULSION TECHNOLOGY has reached a point where, in many cases, it is almost wholly dependent upon fuels for a major breakthrough. It is conceivable that one fuel may be used for thrust advantage, another for high altitude performance, and a third for range extension. Inherent physical and chemical properties would dictate the application chosen.

In some cases, it might seem practical to have multi-fueled weapon systems. However, hardware restrictions might impose limitations to just a dual-fuel type. This concept alone would require extensive modification and advancement of the state of the art of pumps, controls and associated fuel system components.

•

Beware of the man who is usually right—but never in doubt.

•

EVENTUALLY, EMIGRATION into space may become a necessity — for population reasons. Studies have shown that — if the world's population continues to increase at present rates — in four centuries all the land areas of the earth will have population density comparable to Manhattan Island's now. Space travel may become practical just in time!

•

Authority isn't delegated—it's earned. Only responsibility is delegated.

AIRCRAFT FLEETS owned by companies and corporations include more planes, fly more hours, and carry as many individual passengers per year as do the scheduled airlines.

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HOW GOOD IS YOUR MEMORY? How many manufacturers were offering automatic transmissions 10 years ago? How many are offering these units today? When did the industry offer overhead valves, power steering, power brakes, air conditioning, and ball-joint suspensions?

In 1947, just four manufacturers offered automatic transmissions; today there are 19.

Only three car producers offered hydraulic valve lifters in 1947; there are 14 lines of cars so equipped today.

There were only two overhead-valve V-8 engines in 1948; today there are 19.

Power steering was available on just two cars back in 1951; the corresponding number today is 19.

Air conditioning was available from just two producers in 1953; all 19 producers offer air conditioning today.

Ball-joint suspensions were introduced in 1954 by three manufacturers. The number had increased to 13 by 1957.

3 Russian Aircraft Designers and Their 6 Soviet

Secor D. Browne
W. H. Nichols Co.

Andrei Nikolaevitch Tupolev, dean of present-day Soviet designers of transport aircraft, received his education and early training in tsarist days. Born in 1888, he studied under Zhukovski in the Moscow Higher Technical School, where he later worked on the design and construction of wind tunnels and gliders. In 1918, after the Revolution, under Zhukovski he helped organize the Central Aerodynamic Institute of which he was assistant director from 1918 to 1935. Tupolev, or "A.N.T.," as he is known to the general Soviet public, has been responsible for the design of more than a hundred aircraft, principally bombers and transports but including also such sidelines in the early days of his career as aircraft-engine-driven sleds and hydroplanes. Design groups under his supervision were responsible for the huge eight-motored, 52-ton gross "Maxim Gorki" (designer V. M. Petlyakov) in 1934 and the ANT-25 bomber, one of which, the "Rodina" flew over the North Pole to the United States in the summer of 1937. For this particular machine Tupolev is credited with the design of the first Soviet wing anti-icing system. The present "TU" series, TU-104, TU-104A, TU-110, and TU-114 have all been designed by groups under the leadership of Tupolev. His contributions to Soviet aviation have been rewarded by almost all the titles and honors at the disposal of the government: he is a Member of the Academy of Sciences, Lieutenant-General of Engineering-Technical Services, Hero of Socialist Labor, Holder of the Order of Lenin, and a Stalin Prize Winner.

Tupolev is a typical example of a Soviet professional operating within the "multiple-hat" system in Soviet Russia. At one and the same time most engineers, while holding high military rank in their specialty, are designers, researchers. manufacturers, and teachers. The advantages of being able to command and direct basic research for an aircraft of your own design which you will build and sell to yourself might at first thought be appealing, but the disadvantages and peril under a communist government of such centralized responsibility are perhaps equally clear.

Not mentioned in the Soviet glowing biographies of Tupolev is this illustration given by the well-known Russian emigre author P. V. Ivanov-Razumnik of what is meant by "peril" from his experiences during the Stalinist purges of the 1930's:

"In the Lefortovo (prison), according to the stories, they resorted to real tortures — using wire brushes, crushing fingers, and others of this sort — but since I do not know of this from an eyewitness, or, more accurately, from one of the tortured, I will not talk about it. I will only say that, within a year, when I was in cell No. 113 [of the Butyrka prison] in the next cell sat the famous aircraft constructor "A.N.T." — A. N. Tupolev. He told the following about himself: They arrested him and took him to the Lefortovo, assigning him to a cell with the well-known military and Communist Party figure, Muklevitch, who after weeks of Lefortovo "interrogation" had already "confessed" to everything. Muklevitch began to persuade Tupolev to "confess" at the very first interrogation and laid before him a picture of what awaited him in the event of obstinacy. Obviously, the picture was so convincing —Tupolev didn't want to talk about it — that the unfortunate "A.N.T." decided not to undergo personally what had already happened to Muklevitch, and followed the latter's advice. On the very first questioning he confessed to everything the interrogator wanted. They spared him the torture and transferred him to Butyrka, where he awaited the decision of his fate."

Apparently it was not long thereafter that Tupolev resumed his professional duties.

Last September Tupolev's TU-104 completed a year of regular operation on Aeroflot's scheduled routes. Presently TU-104's are in service: Moscow–Kharkov 5219 miles, Moscow–Sverdlovsk–Novosibirsk

Airplanes

1976 miles, Moscow–Tashkent 2068 miles, Moscow–Tbilisi 1563 miles, and fly regularly to Peking and Prague. TU-104's have visited Warsaw, Budapest, Sofia, Bucharest, Paris, London, Delhi, Ankara, Rangoon, and Djakarta, and have made one flight to the United States. Press representatives of Western aircraft industry and other correspondents have flown in and reported on this airplane exhaustively. It has been said that the noise level in the cabin is high and that vibration is objectionable. Pressurization has been reported as inadequate. The weight versus carrying capacity of the aircraft, 75 tons gross to carry 50 passengers, would appear to be highly uneconomical by Western standards, but this criterion is not a matter of importance to an airline which answers neither to stockholders nor to taxpayers.

The TU-104A apparently was designed to overcome some of the objectionable features of the TU-104. Its structure is not as heavy and its passenger capacity has been increased from 50 to 70. The change to more powerful engines, from the AM-3 to an improved model of the AM-209, should have improved the take-off and slow climb performance of the original TU-104.

The initials "AM" which identify these engines introduce one of the two best-known Soviet jet engine designers, **Alexander Alexandrovitch Mikulin** (1895–). His official biography lists much the same "multiple-hat" titles as Tupolev's, but somewhat junior grade: major-general of the Engineering Technical Service, Hero of Socialist Labor, and four times winner of the Stalin Prize, among others. It is interesting to note that Mikulin has been a member of the Communist Party only since 1952, although he has been active in the aircraft engine field since 1923, and that Tupolev is nowhere mentioned as ever having belonged to the Party. Mikulin is officially credited as the father of "the first aircraft engines of original native [Soviet] construction, both piston and jet, bringing them into mass production and use in the Soviet Air Force." His AM-34 piston engine which powered the 1937 Soviet trans-polar flight to the United States was projected by him in 1929 and accepted by the Soviet government in 1931. The early MIG's were powered by the Mikulin AM-35 piston engine and his AM-38F was the power plant of the World War II Soviet dive bomber, the Il-2, and other aircraft. He is credited with originating control of compressor blades and engine supercharging. More modestly, he is only credited with originating the first *Soviet* turbo-compressor and variable pitch propeller.

If the TU-104 and TU-104A differ only in passenger capacity and powerplant, the TU-110, although keeping the TU family resemblance is nevertheless quite distinct. It has four, not two, turbojets and these are from a different designer, **A. M. Lyulka.** Although Lyulka's military version of this engine supposedly powers the YAK-25 and MIG-19 fighters, the official recognition of Lyulka's contribution has been slow in coming. A letter to the official Soviet air force journal *Vestnik Vozdushnovo Flota* two or three years ago complained that such standard texts as the 1953 edition of Skubachevski's *Aviation Gas Turbine Engines* didn't even mention Lyulka, whereas his contribution had been well-known since the 1930's.

Arkhip Mikailovitch Lyulka was born in 1908 and completed the Kiev Polytechnical Institute in 1931. From 1931 to 1933 he worked in the Kharkov Turbo-Generator Works, and from 1933 to 1939 in the Kharkov Aviation Institute where he developed the "theory of the turbo-compressor and the air reaction engine" and in the years 1937–1939 built the first turbojet engine. Some Soviet sources refer to this work as being a world "first," coming long before the efforts of Sir Frank Whittle and others.

Lyulka's engines used on the TU-110 are estimated to have a thrust of 8500 lb — less powerful but also with lower specific fuel consumption than the Mikulin engines of the TU-104.

The passenger capacity of the TU-110 is 78 in the luxury version, and 100 in the tourist. In addition to the 100 passengers, the Soviets claim this aircraft will carry 3500–4500 lb of baggage and 4500–6400 lb of mail and cargo, or a total of 12 tons of payload. Unlike the TU-104 the engines are in the wing roots of the TU-110. It is claimed that in consequence of such engine location the noise level in the cabin has been substantially lowered and other improvements and lightening of the fuselage were made possible. The lengthening of the nose section has increased the length of the TU-110 by 4 ft over the TU-104. The galley, which on the TU-104 was mid-fuselage between the two passenger cabins, has been moved forward to facilitate the loading of food. Soviet descriptions of the galley equipment empha-

This is Part II of a two-part article. Part I in last month's issue dealt with Sergei Ilyushin and the IL series of transport aircraft and O. K. Antonov and the AN series.

3 Russian Aircraft Designers and Their 6 Soviet Airplanes

Continued

size in considerable detail the facilities for serving a variety of hot food and drinks. It is not explained why, but the crew compartment is divided from the passenger area by a "hermetic partition." The passenger area itself is divided into three cabins: forward cabin for 30 passengers, a middle cabin for 15, and the rear cabin for 55. Seats are five across, divided three and two; they adjust 40 deg from the vertical and have removable arm rests. The middle cabin has cradles for infants. Clothes racks are by the rear cabin door. There are two lavatories at the rear of the plane equipped with flush chemical toilets, using electric pumps between chemical supply and waste tanks.

It is said that the "practical length of flight" of the TU-110 with a 12-ton payload is 1900–2100 miles. Cruising speed for such a flight is given as "reaching" 500 mph at an altitude of 33,000 to 39,000 ft and maximum speed of the TU-110 as "reaching" 621 mph.

As for operating cost, "the cost per ton-kilometer with a 12-ton payload approaches the cost of transport on turboprop passenger aircraft." This rather vague statement is used by Soviet writers in their attempt to controvert the prevalent idea that turbojet aircraft are practical only for long-range operation and that aircraft such as the TU-104, TU-104A and TU-110 can be successfully used on flights of 600 miles or greater. Moreover, it is said that on flights of "less than 1700–2300 miles these aircraft can operate at a cruise speed of up to 560 mph which increases the effectiveness of their use." One thing is fairly certain, if this is the Soviet theory of operation, the Soviet statistics will confirm it!

Most recent Soviet transport to bear Tupolev's name is the TU-114, a four turboprop aircraft claimed to be capable of transporting 120 passengers from Moscow to New York in 10 to 12 hours, along with a crew of ten. Some of the 10 crew members presumably will busy themselves with the unusual features such as a projected 48-seat restaurant, telephone switchboard, and two elevators. Although one source stated that for shorter flights the passenger capacity can be increased to 220, other sources specify 170 and 180 passengers.

In announcing the new aircraft it was stated that it had made several test flights with dazzling results." A photograph of the TU-114 in flight makes it appear to be a greatly enlarged version of the TU-104 and TU-110. It has four turboprops mounted in nacelles which project very far forward of the wings. It may well be that this aircraft is, as the Soviets claim, "the biggest passenger airplane in the world," for whatever this distinction may be worth. The "Rossiya," as the new 200-ton TU-114 has been named, is stated to have four 12,000-eshp turboprop engines, and to cruise at 500 mph with a range of up to 4300 miles.

Landing Gear has long oleo for Russia's rough runways. Note radome.

TU-104A Serving Copenhagen Illustrates Russian Design Ideas

Report to the SAE Aircraft Activity Committee by **HUGH HARVEY,** Shell Oil Co.

A Russian TU-104A turboprop transport is scheduled to arrive at Copenhagen's Kastrup Airport early each Friday afternoon and take off again that evening to return to Moscow.

These photographs show the aircraft when this commercial operation began last December. The service is operated by Aeroflot, the civil transport arm of the Soviet Air Force. In Copenhagen, ground service is provided by Scandinavian Airlines System.

The Moscow-to-Copenhagen flight is scheduled to take 2 hr. 25 min. for 964 miles. The inaugural flight made the trip in 2 hr. 15 min. (SAS, which also operates one flight in each direction per week, requires 4-hr. for the trip in its current piston-engine equipment.)

The TU-104A lands with the characteristic high turbine-engine whine. But airport employees say they find it no more disturbing than the Viscount or the DC-7C.

TU-104A on Moscow-Copenhagen run features overhead racks of white cord netting on gold-colored frames. Pearly bowls soften overhead lighting.

Wing Fences may be fixes for insufficient lateral stability.

TU-104A Turboprop transport also has tail skid for short-runway use. Plane is shown at Kastrup Airport.

Abridged from an
SAE Dayton Section Paper

Electronic Computer Serves As Engineering's

Based on paper by

D. G. Thoroman

International Business Machines Corp.

FIVE areas where electronic computers are being used as a tool to aid in the solution of engineering problems are:

1. Design
2. Model simulation
3. Data reduction
4. Statistical computations
5. Operations research and management science

design

The design of a new product (or of an improvement to an already existing product) requires inductive reasoning and imagination. The computer can furnish neither—it has only deductive ability. The usefulness of the computer in design is to assist in the evaluation of hypotheses, never to hypothesize!

Specific product applications of the computer include: gear design, cam design, electrical transformer design, airfoil design, propeller design, and electrical motor design. In all of these, it is possible to state the problem to be solved mathematically, and then perform parameter studies to arrive at the design which is theoretically best.

Some advantages of the use of computers in design are:

1. One can arrive at the best theoretical design by considering the effect of more parameter changes.
2. The accuracy of the final results is very high. This is due to the fact that human error can be eliminated. Also, a computer enables desk calculator accuracy in all computations.
3. There is a reduction in the number of models required due to arriving at the best theoretical fit before the models are built for testing.

model simulation

It is possible, in many cases, to construct a mathematical model which can be manipulated, using the computer, to test the effect of various changes in the product. For example, one automobile manufacturer has constructed a mathematical model of an automobile to test such things as: What is the effect on performance, acceleration, and such of (1) adding 300 lb to the weight of the car, or (2) increasing engine displacement by 50 cu in.?

These questions can be answered without constructing a physical model and subjecting it to tests—a computer gives the answer in minutes. Other specific models include a model of a condenser for refrigeration systems and a model which allows testing an airplane's performance (flutter, and such) by use of an electronic computer.

The principal reason for using computers for model simulation is that the cost and time involved in model building can be greatly reduced.

data reduction

A third use of computers in engineering is in what has come to be called data reduction. This nomenclature might be defined as a mathematical transformation of data expressed in one form to data expressed in another form or unit. For instance, in wind tunnel testing one can measure and record pressures and forces, and then apply a set of arithmetic operations on this data to arrive at aerodynamic units such as coefficient of lift and coefficient of drag. Many devices record a voltage which then must be converted to other units.

The computer serves a very useful role in data reduction because it allows fast conversion of raw

5 Areas

Newest Tool

data for quick evaluation and because it gives a very elaborate analysis of the data which, in turn, gives a greater return from the test.

statistical computations

A fourth, and very significant, use of computers has been for statistical computations. When one considers that many of the engineering sciences are to date empirical, it follows that there is a heavy reliance on statistical methodology.

Statistical computations are normally simple but voluminous and laborious. For example, calculating multiple regression coefficients for a set of n variables involves solving a set of linear equations of order n. The number of arithmetic operations to solve a set of linear equations is approximately the cube of the order of the set. For a set of 100 linear equations, this means that about 1,000,000 arithmetic operations are necessary. A large scale computer can arrive at the solution of 100 simultaneous linear equations in about 10 minutes.

Common computer applications are: calculation of means and standard deviations, simple correlation coefficients, least squares curve fitting, multiple regression analysis, analysis of variance, and factor analysis.

operations research and management science

The last general area which will be mentioned is the use of computers in operations research and management science.

The techniques of linear programming, for instance, wherein a set of linear restraints and an associated linear function are to be solved optimally, have been very useful in petroleum engineering. Here one is concerned with determining which end products to produce from given crude oils, so as to maximize profit. The solution depends on demand for each possible product, profit for each product, and the quantities of each product that can be produced from each unit of the various crudes available.

To Order Paper No. S40 . . .
. . . on which this article is based, turn to page 5.

the logical dissection of a *MODERN COMPUTER* would result in five parts:

- An input device of some sort to allow the computer to ingest data. Conventional devices used for input currently are punched cards, punched paper tape, and magnetic tape. Because of its speed (up to 60,000 characters per second), magnetic tape is most commonly used.

- To allow communication from the computer, output devices are required. In addition to the same media used for input, common devices are the line printer (up to 1000 lines of 120 characters each per minute) and cathode ray tube display units.

- A unit to remember (store) both instructions and data fed into the computer. Medium scale computers commonly use a revolving cylinder (drum) to store information in the form of coded magnetic bits. Most large scale computers use tiny ferrite rings (magnetic cores) to store information magnetically.

- In order to compute, there must be an arithmetic unit. Computing speeds are probably the most unbelievable of all the characteristics of modern computers. Commercially available computers are capable of over 40,000 arithmetic opertions per second.

- The characteristic of the electronic computer which has led to the term "giant brain" is the ability to discriminate. It is this ability which allows such applications as language translation. This ability is probably the greatest untapped source of usefulness for electronic computers.

Battle to Quiet Cars Grows Hotter

Ford's new bump rig helps find basic cause of noise in prototype vehicles, so changes can be made before production starts.

Based on paper by

R. H. Bollinger and H. N. McGregor

Ford Motor Co.

FORD has developed a bump rig which enables the pitched or period-type noise to be distinguished on the basis of its frequency, amplitude, and whether or not it is torque sensitive. These characteristics provide important clues to the basic cause of noise in prototype vehicles so that remedial action can be taken to correct it before production is undertaken. This is very necessary in view of the many design factors tending to make cars noisier.

Bump Rig Construction

The rig is essentially a chassis dynamometer located in an anechoic room, 30 × 30 by 20 ft high. Room surfaces are covered with fiberglass wedges 40 in. in depth. This makes the room echo-free and anechoic, thus simulating road acoustic conditions. High-frequency sound is almost completely absorbed, but below 50 cps the absorption efficiency of the room drops off.

The main floor is built of a heavy grille, separating the room level from a lower sublevel. The rolls are cast steel, 6 ft in diameter and mounted on a concrete pedestal with a separate isolated foundation. The vehicle under test is at the main floor level with either front or rear wheels on the rolls. Over 600 hp can be absorbed from the rear wheels with tire breakaway torque the only limiting factor. Current production passenger cars can be held to less than 10 mph, wide-open throttle. When used for suspension tests, sinusoidal cams or sharp-edged cleats can be attached to the rolls. With the variety of cams available, the vehicle suspension can be excited at ride, wheel hop, and shake frequencies.

The torque sensitivity of a period often can be determined by observation. If a period can be made to come and go by depressing and releasing the accelerator while maintaining a fairly constant speed, it is torque sensitive. The frequency of a period is, perhaps, the most valuable identifying clue and it can be determined by a frequency analyzer which gives a chart (Fig. 1) pointing out the major frequency component or components of the noise. Knowing this and the car speed, it is a simple matter to identify the offending part by an "alignment chart."

The alignment chart (Fig. 2) is a graph of vehicle component frequency (usually the ordinate) versus car speed. It is easily prepared by laying off on the abscissa the vehicle speed from zero to the maximum

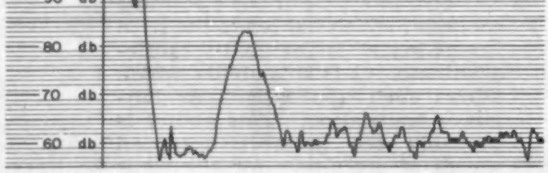


Fig. 1 — Frequency of a period noise is the most valuable clue to identification of cause. A frequency analyzer provides this analysis of vehicle interior noise (at 56-mph period), pointing out the major frequency component or components of the noise. From this the alignment chart is prepared, as shown in Fig. 2.

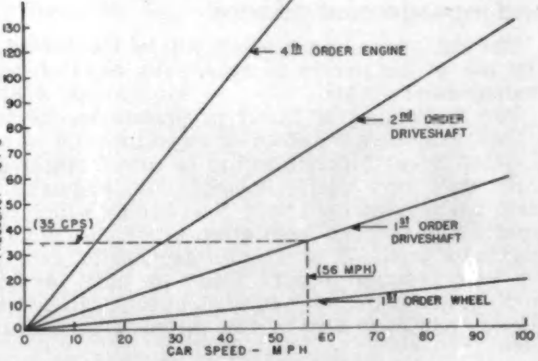


Fig. 2 — This alignment chart is a graph of vehicle component frequency versus car speed. It serves to identify the offending part, an essential step in curing cause of noise.

encountered (0 to 100 mph is a convenient range), and on the ordinate the frequency from 0 to the maximum expected (0 to 150 cps will suffice for most cases). The rotational frequencies of the various car components are then plotted as a function of vehicle speed. With reference to the frequencies shown in Fig. 2, by first order is meant the rotational speed of the component in cps, second order is twice the rotational speed, and so on. From our hypothetical frequency spectrum at 56 mph (Fig. 1) our 35-cps noise component would be first-order driveshaft.

Knowing the offending component pinpoints the two ends of the transmission path: at the one end the listener's ear or some vibrating contacting component, at the other the sources of vibration. Some of the main sources of this type of pitched noise are:

1. Engine unbalance (first-order engine).
2. Engine firing impulse (fourth-order engine for eight cylinders).
3. Driveshaft unbalance (first-order driveshaft).
4. Universal joint vibration (second-order driveshaft).
5. Wheel and tire eccentricities (first-order wheel plus higher orders).
6. Gear noise (tooth contact frequency plus higher harmonics).

Knowledge Leads to Cure

Identification of the original sources of vibration forces can sometimes lead directly to a fix. First-order engine or driveline vibration, for example, usually can be eliminated by careful balancing; second-order driveshaft vibration, by reducing universal joint angles or by rephrasing the yoke angles. Originating forces may be quite small yet be accentuated by a resonance occurring somewhere along the transmission path. Here the general attack is to eliminate or damp out the resonance, first by finding the resonating part, then either raising or lowering the resonance out of the critical speed range, or damping the component vibration to a point no longer offensive.

To Order Paper No. 2B . . .
. . . on which this article is based, turn to page 5.

Anti-Collision Devices for Aircraft . . .

. . . to extend or replace the sensory, computing, and response functions of the human operator are of increasing interest. We must keep the aircrew's response capabilities in mind in designing the devices.

By Wilson Wong

Human Engineering Analysis Group
Northrop Division, Northrop Aircraft, Inc.

INVENTION of anti-collision devices to extend human functions recognizes the limitation of human visual senses for detecting aircraft, due to restricted view from cockpits, the lack of aircraft conspicuity, and the physiological limits of the eye. Critical time factors in collision-course situations require either that display of instruments transmit information to the aircrew in a manner to minimize operator reaction time, or that an automatic collision-avoidance system be used. For example, for avoidance only 11 sec warning is available between two 500-knot aircraft first detected at 3 miles in a head-on collision course.

The development of sensory equipment to augment the visual search function of man is a major step toward an automatic collision-avoidance system which would bypass the man in all operations, taking advantage of certain machine characteristics in arriving at the appropriate control action in the shortest time possible. Much investigation and testing are required before there will be operational detection equipment with adequate range, coverage, and reliability, not to consider the computing and control functions. Until sensed position data can be translated unequivocally into control responses by computer programs, the superior attributes of judgment and flexibility in man are required in the evaluation of each threat situation.

While man has an essential decision function in warning systems, the question of optimum allocation of system functions between automatic action and human intervention is a fundamental area of human engineering investigations. Here the primary human interactions are centered about display and control functions, and even a cursory assessment of information-display problems in collision-warning systems indicates that speed and accuracy of operator response are critical factors. (However, little attention has been given to human factors in the display function of some anti-collision systems proposed recently.)

It has been demonstrated experimentally that human reaction time increases as a function of the number of stimulus alternatives, and is directly proportional to the average information transmitted from the display to the response (where information is defined according to the Shannon formulation in communication theory). Although the number of signals that could appear simultaneously on a warning display depends on traffic density conditions and machine limitations, the capacity of the display and the amount of information to be presented for each aircraft should also be considered in terms of human capacities. Data such as range, azimuth, closing rate, and elevation angle would pinpoint each intruder aircraft. But the gain in information should be weighed against the time requirements for processing and comparing this information.

Under laboratory conditions, when the operator

is anticipating the onset of one of two visual stimuli, a typical time of 0.25 sec is required for initiation of the alternative right or left side key-pressing responses. In-flight tests at Wright Air Development Center show that reaction increases to about 2.5 sec for similar visual indications to pilots flying a C-131B in local transition. Another 3.5 sec should be added to the total reaction time to include the time required for getting the aircraft into a 45-deg bank.

A command indication alone would minimize stimulus information, thus avoiding clutter and establishing conditions for quicker reaction time. However, in this case, providing that the corrective action could be specified, a machine could react even faster.

The nature of the display signal, as perceived by the operator, is another variable that may adversely affect reaction time. Perceptual confusion concerning the "trouble" and the corrective action required could be reduced by using distinct kinds of indications. Thus, "alarms," referring to immediate danger, and "warnings," indicating potential danger should be differentiated. This distinction is also the essential difference between collision-warning, and proximity-warning systems. Utilizing different human senses would permit easier signal discrimination. Operator uncertainty as to the intent of the display increases his reaction time.

Research on the stimulus-response compatibility of displays shows that optimum performance depends more upon the interaction of the stimulus display with the control characteristics than upon the primary effects of either of these alone. Conflicts between display and control arrangement, in one experiment, have increased the reaction time over 1½ times and almost doubled the percentage of errors over that obtained with a compatible arrangement.

A combination of several flight parameters on one instrument may result in a more natural representation of stimulus information. Combined data are generally more easily interpreted when presented on pictorial displays; spatial relationships, especially, are interpreted more quickly with fewer errors.

Training in the understanding of system limitations, and past experience with the particular system, are major determinants in how the operator will react to the next signal. If, in a high task load or stressful situation, the operator tends to react "according to habit," the system should be such that it minimizes interference with these habits and perceptions. In addition, unless the warning system limits the number of spurious warnings, the operator response will be less predictable, and his tendency to mistrust or ignore the signal will be reflected in a delayed reaction.

The display exists for the purpose of transmitting information about the system to the human operator. The discriminatory response of an organism to a stimulus, according to one definition, constitutes the evidence of communication; thus, the operator efficiency is increased by providing optimal conditions for communication. For increased system effectiveness, operator efficiency should not be sacrificed for engineering efficiency in equipment design and operation.

Missile

. . . are laboratory experiments

Based on talk by

Major-Gen. Donald N. Yates

Air Force Missile Test Center

Air Research & Development Command,

Patrick Air Force Base

FLAWS in missile design and performance cause malfunctions which usually result in flight termination by command or accident. The press generally reports these terminations as failures, although many represent successful tests. An example of this is the need to command a missile beyond its design tolerances for the specific purpose of determining the exact failure limit.

On the first Atlas shot, 95% of the test objectives were achieved although the missile flew for less than one minute. Similarly with tests involving the "big" missiles, even though many of them terminate within minutes or even seconds of launching.

A ballistic missile flight of only 15 min will yield 250,000 discrete data points (individual readings), such as instantaneous temperatures, switch positions, and pressure velocities. With missiles which have experienced malfunctions or failures, it is the rule rather than the exception that analysis of the data reveals precisely the cause of the malfunction.

The purpose of tests is to record performance. We must measure the position of missiles in space during all critical portions of flight. This can be done to an accuracy of a few inches with relative ease by using high-speed cameras when missiles are within a mile or so of the launch area, or to an accuracy of about 30 ft for ranges up to 15 miles by using theodolites and extending this range by modern radars. The high-speed camera used is shown in Fig. 1.

On the other hand, to measure the position of ballistic missiles traveling at 10,000 to 15,000 mph at altitudes of several hundred miles requires the ultimate in electronic phase comparison techniques. The equipment measures direction cosines to an ac-

An Abridgment of an

SAE Detroit Section Talk

Flight Tests

to determine flaws. Successful "flops" are steps on the road to perfection.

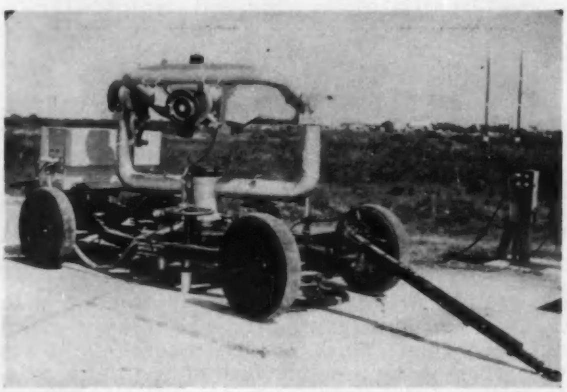


Fig. 1 — High-speed camera which enables position of missile to be measured to an accuracy of a few inches when within a mile or so of the launch area.

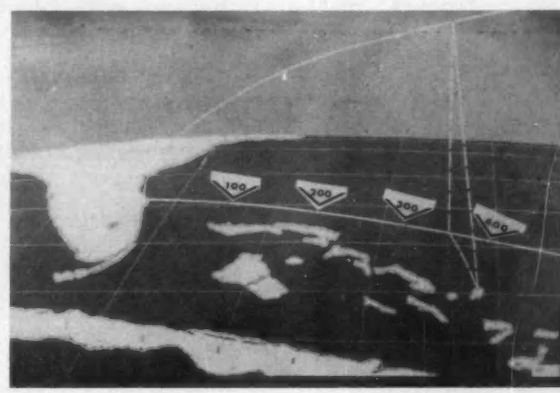


Fig. 2 — Schematic of trajectory showing the downrange tracking of a missile so that third stage can be fired the instant the flight path becomes parallel to the earth.

curacy of 2 parts per million and can detect change in position of 15–30 ft up to a range of 500 miles.

Trajectory Problems

The Vanguard project well illustrates the complexity of the instrumentation problem. In order to achieve a circular trajectory of the satellite around the earth, instead of a flattened or elliptical one, we must be able to track the Vanguard after its second stage has fired, and compute the exact time the flight path becomes parallel to the earth so that the third stage can be fired at that instant, boosting the satellite to orbital velocity. This is accomplished by tracking the missile by radar from a downrange island station, transmitting the radar data to the launch base at Cape Carnaveral via a submarine cable, computing the time to fire the third stage in an IBM 704 computer at the Cape, then automatically transmitting a third-stage firing signal to the vehicle at the proper instant from an inland station 300 or 400 miles downrange. A schematic of the trajectory is shown in Fig. 2.

Missile developers have imposed rigid photographic requirements in order to observe and study the characteristics of missiles, such as flame patterns, stability, autopilot response, booster ejection, and staging. Cameras having a 500-in. focal length are used to take pictures of missiles in flight at ranges up to 200 miles.

Telemetering affords the principal source of information on what is happening inside missiles. Telemetry data are received on as many as 175 separate functions on each flight, which may give as many as the 250,000 data points, already mentioned. Four antennas enable coverage of the 5000-mile trajectory of a missile.

After the firing, all of the data, the magnetic tapes, the radar plots, and the upper atmosphere soundings are rushed to the data reduction facility where the raw data are fed through automatic reduction processes. In a matter of days, the end result of the thousands of man-hours expanded is a Flight Test Report, one more forward step on the long, hard path in the development of missiles.

Solid-State Physics Unveils Atomic Mysteries

Scientists are beginning to understand what goes on inside materials. Advances due to solid-state physics primarily have been in electronics but the future will bring superior materials for all fields.

Based on paper by

Michael Ference, Jr.

Ford Motor Co.

DEALING with the intrinsic behavior of electrons and atoms in solids, solid-state scientists are obtaining "inside" knowledge of such phenomena as semiconductors, surface behavior of materials, superconductivity, magnetic resonance, photoconductivity, luminescence, and electroluminescence.

These, however, are but a shadow of the potentialities of this new science. Once the atomistic nature of materials is mastered, scientists will be able to provide radically new properties and revolutionary materials that defy conception in terms of present-day experience.

This article reviews some of the advances of this new technology and presents highlights of some of the newer ideas being considered in the research laboratories.

Semiconductors—The Transistor

Early in the studies of solids it was recognized that there exists a class of materials whose electrical properties fitted no pattern among the then known materials. Unlike ionic salts, conduction in these materials was not by ion transport—in fact, conductivity was often much greater than in the simple stoichiometric ionic salts. Although some of the materials exhibiting such properties, for example silicon and germanium, are metallic in appearance, the electrical conductivity observed was considerably smaller. But most unusual, the temperature coefficient of resistance was negative in sharp contrast to metals as shown in Fig. 1.

The first really major success of what we now call the band theory of solids was its explanation of so many of the observed properties of these so-called semiconductors. What the physicist postulated was that when atoms are put together to form a solid, their individual energy levels merge to form a band that has a finite width on an energy scale but which can be separated one from the other as shown at the top of page 37.

In a semiconductor the valence electrons occupy all possible energy levels in the "valence band". The next highest energy band is separated from the

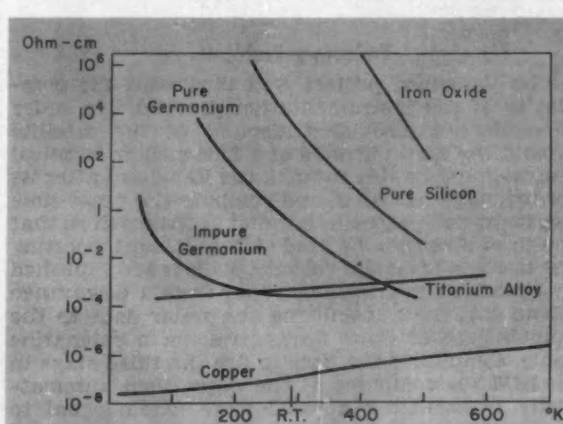
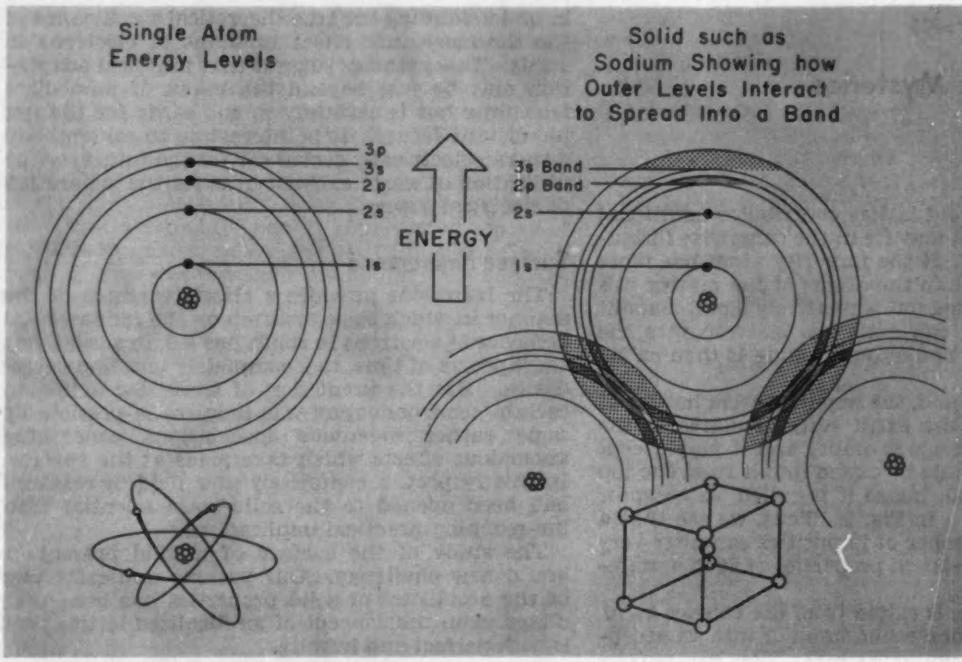


Fig. 1 — Variation of electrical resistance of some typical metals and semiconductors.



ENERGY STATES IN AN ATOM AND SOLID — At the left are shown the separated energy levels of an individual atom of sodium. At the right are shown the overlapping energy levels of the sodium atoms of a body-centered cubic lattice, suggesting the formation of energy bands. The lower levels are still sharp, the outer levels have broadened into bands.

filled one by an energy gap (about 0.7 ev for germanium). So long as the lower band is completely full, the electrons contained in it cannot possibly conduct electricity, for imparted motion to the electron implies the addition of kinetic energy but there are no new energy states allowable.

In all insulators this is precisely the case since the "conduction band" is at a much higher energy so that to all intents and purposes there is no possibility of conduction.

In an "intrinsic semiconductor" the energy separating the valence band from the conduction band is sufficiently comparable to thermal energies that a finite number of electrons can be thermally exited into the conduction band and thus contribute to the conductivity. Statistical thermodynamics not only tells us that this number will increase with temperature and thereby explain the negative temperature coefficient of electrical resistance but also provides a means of calculating precisely the number and temperature dependence.

In the case of a simple metal such as sodium, copper, and silver, the valence band is only partly filled and electrons near the top of this band may absorb energy from an electric field and hence conduct electricity.

It is now easy to see why semiconduction is so sensitive to impurities. An impurity which replaces

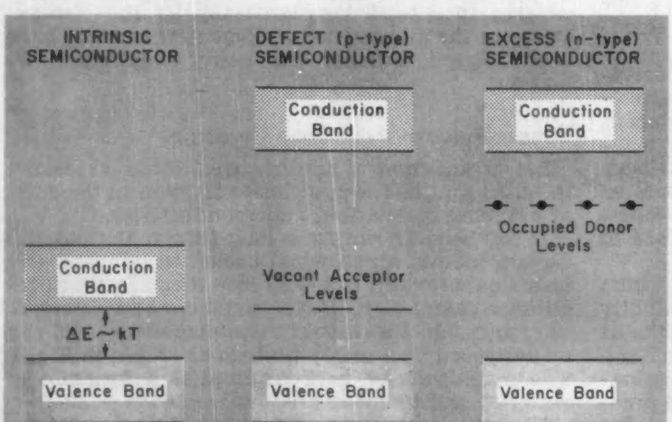


Fig. 2 — Energy band picture of an intrinsic semiconductor, and defect and excess impurity semiconductors showing impurity energy levels.

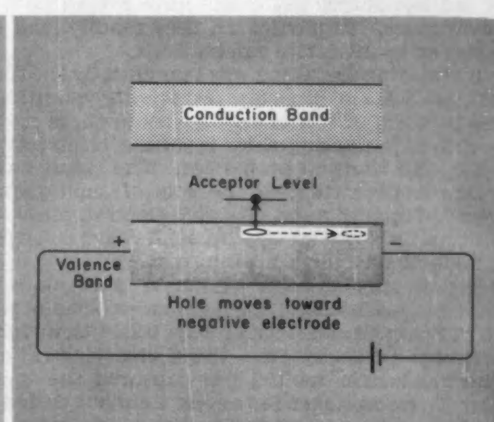


Fig. 3 — Conduction by holes in a defect (p-type) semiconductor. The hole moves against the electric field.

Solid-State Physics

Unveils Atomic Mysteries

continued

an atom in the parent lattice contributes additional energy states which may lie in the otherwise forbidden energy region. If the impurity atom has more valence electrons than the atoms of the matrix this state will be occupied but a relatively small amount of thermal energy can exite the electron into the conduction band. The impurity state is then called a donor level.

If, on the other hand, the impurity atom has fewer valence electrons, the extra state or states in the forbidden energy range is empty and it may accept an electron that would be exited into it from the top of the valence band, hence it is called an acceptor state. This is shown in Fig. 2. Thus, we see that a relatively small number of impurities can alter very appreciably the electrical properties of such a material.

When an electron is exited from the valence band, whether into the conduction band or into an acceptor state, it leaves behind it a hole. This hole may be viewed as a positive charge in the sea of electrons and thus can also contribute to conduction. An electrical model for the motion of a hole against an applied field is shown in Fig. 3.

The discovery of the transistor was a direct outgrowth of the "hole" hypothesis. It was, in fact, a consequence of the recognition that some of the anomalous observations of the electrical properties of semiconductor surfaces can only be explained by assuming an unusual preponderance of holes in the neighborhood of the metal contact.

From this relatively simple concept grew the transistor industry, for, it was only a short step from the recognition of what was going on inside the semiconductor to the enslavement of the effect for practical good.

But the understanding of the electronic nature of a semiconductor has brought with it more than just the transistor. It soon became evident that models of semiconductor materials have certain attractive advantages. In particular, they readily lend themselves to quantitative calculations.

A major undertaking was launched by the theoretical solid-state physicist at solving quantitatively the problem of the energy states in these materials and thus predicting their resulting electrical, magnetic, and thermal properties. The result has been a new appreciation of the role of such factors as electron mobility and effective electron mass (a new concept introduced by the solid-state scientist) in influencing all sorts of properties.

Let us look at some of the by-products of this: man has talked for many years about the possibility of utilizing in a practical way, other than for temperature measurements, the thermoelectric effects. Thermoelectric cooling has captured the imagination of the engineer for a long time but defied practical embodiment because of the smallness of the effect and the low coefficient of performance of a thermal engine. But great strides have been made in understanding the true theoretical significance of the thermoelectric effect in terms of electrons in solids. These studies suggest that practical adaptation may be just beyond the realm of immediate feasibility but is certainly in the cards for the not too distant future. It is interesting to contemplate a thermoelectrically cooled car for the future, or the utilization of waste exhaust heat for the generation of electrical power.

Surface Phenomena

The transistor provides a classic example of the manner in which basic research on the fundamental behavior of electrons in solids has led, in a relatively short period of time, to a completely new and useful device. But the prediction of transistor action in certain semiconductors was only made possible by some rather ingenious speculations concerning anomalous effects which take place at the surface. In this respect, a completely new field of research had been opened to the solid-state scientist with far-reaching practical implications.

The study of the surface of a solid presents a brand-new challenge. Our present understanding of the atomistics of solid properties has been predicted upon the concept of an idealized lattice that is both perfect and infinite.

There is, however, a close dependence of structure-sensitive properties on the degree of perfection, and we can expect unusual properties to accompany a more complete understanding of imperfections.

A substantially similar extrapolation can be inferred for the understanding of surface properties, and here too we can surely anticipate a myriad of new properties and new materials.

As an example of how solid-state science is opening up a new frontier of knowledge, consider the new class of materials known as cermets. These are finely dispersed ceramic materials bonded together with a metal or alloy binder and show remarkable mechanical and wear behavior. It is not completely clear why this should be so, but if the mystery can be unlocked, a veritable treasure of new materials with undreamed of properties will be unfolded. It has been found, however, that the critical parameter is the tendency of the metallic binder to wet the surface of the ceramic. This, in turn, has been discovered to depend very critically on the electron states in the alloy system. Some new cermets have been created utilizing this newly acquired information.

Superconductivity and the Cryotron

Let us turn now to another area of basic research in solids that has seen ultimate fruition in the form of practical realization: superconductivity.

It has been known for a long time that there are certain metals which when cooled to temperatures near liquid helium (−450 F) lose their electrical resistance completely. But a particular characteristic of superconductors is that the superconductivity can be destroyed by a magnetic field as shown in Fig. 4. The magnitude of field required is a function of material and temperature.

Recently, an important application for the superconductivity phenomenon has been discovered which may well reorient all of computer technology

—this is the cryotron. It can be used as a memory element for computers and utilizes the principle of destruction of superconductivity by a magnetic field.

By using a very fine superconducting wire and an equally fine coil wrapped around it plus appropriate circuitry designed to detect whether at any given instant the wire is superconducting or not, an effective binary memory element can be made. In a recent embodiment of this invention, it was indicated that a computer can be constructed containing 300,000 such binary elements in a volume of 1 cu ft—a thousandfold gain in volume over conventional circuitry.

By utilizing niobium and tantalum, whose transition temperatures differ, it is possible to design a superconductive amplifier that operates at liquid helium temperatures without conventional tubes or transistors. The magnetic field is the control element.

Magnetic Resonance and Masers

We turn now to another area that has led in a very short span of time to another new method of electrical amplification.

A rather interesting and exciting field of physics that has grown up since the war is that of nuclear and paramagnetic resonance. An atom in a paramagnetic material has a permanent magnetic moment as do most of the nuclei. Classical electromagnetic theory tells us that in a magnetic field this moment will precess about the field at a calculable frequency and that if high frequency radiation of the same frequency is pumped into the system, the elementary magnets can absorb a detectable amount of energy from the radiation field. A completely equivalent quantum picture can be drawn of this process utilizing the concept of energy states in a magnetic field and transitions between the states excited by quanta of electromagnetic radiation.

The solid state scientist recognized at an early stage in the development of this field its potentialities as an analytical tool. The resonance technique provides a probe which can penetrate into the interior of a solid and by determining the local fields at a nucleus or paramagnetic atom provide much information about the structure and molecular architecture of solid bodies.

A year or two ago, a major application for this phenomenon was uncovered which bodes well to give a new dimension to communications technology. A more than cursory scrutiny of the scientific basis of this development should prove rewarding. In order to illustrate this point, the quantum approach will perhaps be more suitable.

An elementary atomic magnetic in a field can have two possible energy states—parallel to and antiparallel to the field. At any given temperature, there will be a statistical equilibrium distribution for all the atomic magnets among the two possible states with the lower of the two more populous. Applying electromagnetic radiation of the proper frequency can cause transitions between the two states resulting in power absorption if the transition is upward and in emission if the transition is downward.

For emission to take place, there must be some method by which the energy can be exchanged between the magnet and the outside world—a technique called the "relaxation mechanism." We can readily conceive in principle and realize in practice a situation in which we can pump power into a device with a pulse of high frequency radiation, causing the upper state to be more highly populated than the lower as shown in Fig. 5. If then an external radio signal of that frequency is incident upon the system, it will stimulate the emission of additional radiation by causing the system to "relax." Thus we have, in effect, an amplifier in paramagnetic systems at reasonable laboratory fields. The energy gap between levels corresponds to radiation in the microwave range of frequencies, hence the name Maser—microwave amplifier by stimulated emission of radiation.

Bloembergen of Harvard recently outlined theoretically a method for the continuous operation of

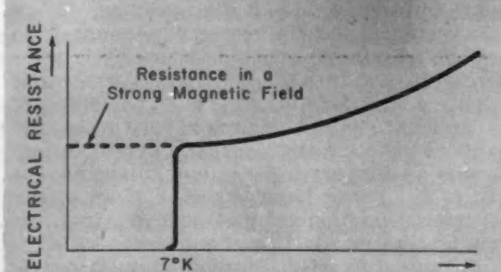


Fig. 4 — Variation of electrical resistance with temperature for a typical superconductor (lead). The dashed curve shows the behavior in the presence of a strong magnetic field.

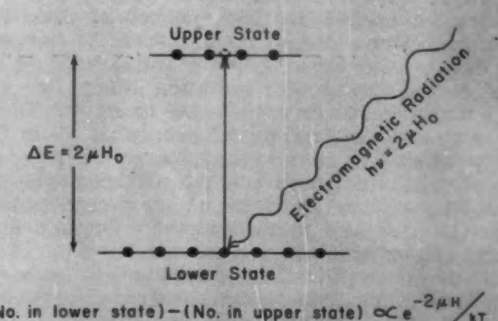


Fig. 5 — Statistical distribution of magnetic atoms among possible states in magnetic field H_0. By absorption of radiation of frequency $2\mu H_0$ the population of atoms in the upper state can be significantly increased.

Solid-State Physics

Unveils Atomic Mysteries

continued

a Maser as an oscillator. Scovil and his associates at the Bell Telephone Laboratories constructed such an oscillator operating at about 9000 mc, by using a 17,500 mc power supply and a 3000 gauss magnetic field. The solid used was lanthanum ethyl sulphate doped with gadolinium. The remarkable feature of this type of amplifier is that it can be used at very low temperatures and as a consequence has a very low noise factor (nearly zero db). Thus with Masers, one may talk of signal-to-noise ratios previously unheard of in microwave technology. This means that the microwave frequency regions now offer potential for long distance communication since it will now be possible to detect very feeble signals. Already Masers are being used in radio astronomy where this signal-to-noise feature makes all the difference between detection and nondetection of signals.

Photoconductive, Luminescent, and Electroluminescent Materials

Perhaps one of the most intriguing areas of application of semiconductor-like materials is that concerned with luminescent and photoconductive materials.

With the advent of the transistor and the solution of the problem of why such materials behave as they do, the secret of photoconductivity, particulary in the infrared, and perhaps to a lesser extent of luminescence began to be unveiled. Let us examine this from the energy band point of view.

Suppose that the gap in energy between the top of the highest full band and the bottom of the conduction band corresponds to just the energy associated with, let us say, infrared radiation. In that case, exposure to infrared would cause a particular material to be highly conductive. This, in essence, is the principle of the infrared detector cell. Unfortunately, nature provides us with just a limited number of materials whose energy gaps just fit the particular radiation energy which we may desire.

Since an equally efficient method of making a semiconductive material conductive is to have the gap between an impurity state and a band equivalent to the appropriate radiation energy, we may molecularly engineer a material to fit our needs. For example, suppose we can conceive of an impurity which places a vacant state of exactly the indicated energy above the top of the conduction band, then this behaves just as our acceptor states do in the case of a semiconductor. The oncoming energy excites an electron from the top of the filled band and conduction then takes place by means of holes. Utilizing this concept, extremely sensitive infrared detectors, previously inconceivable, have been devised.

An important by-product of the understanding of the photoconductive process is the invention of a new duplication or printing process known as xerography. Fig. 6 shows schematically the manner in which this method of duplication operates. When light strikes a photoconductive surface, those areas that are struck by the light become photoconductive. Thus, if a metal plate backs up a photoconducting material, the surface of which has been charged, the charge can leak off in the areas that have been struck by the light. If pigment particles are subsequently passed along the surface, they will stick in the charged regions and skip completely the uncharged regions and thus provide a positive print. This provides a very efficient process for printing with resolutions of 10 lines per mm attainable and printing speeds of 1200 ft per min possible.

Just about the time that the cathode ray presentation of data on naturally occurring phosphors looked feasible enough and fast enough to be useful in television communication, the strides in understanding matter made it possible to devise new and better materials which would be photosensitive and which would luminesce when struck by either electron beams or by light of one form or another. Today we can conceive of a variety of potential applications which await only the more precise evaluation and discovery of methods of inducing specific sensitivity in luminescent materials.

Luminescence is not completely unrelated to what we have discussed in connection with electron exitations in semiconductors. As a matter of fact, it is almost the precise inverse of photoconductivity. whereas in photoconductivity light is absorbed givcing rise to excitation of electrons from a lower state to an upper state, in luminescence the converse is true—it is the electron which is somehow trapped metastably in a state of higher energy and releases its energy in the form of electromagnetic radiation in the process of degrading itself to a lower available state.

The principal difference between the types of materials which are the prototypes of luminescent materials and the usual semiconductors is that an unusual combination of circumstances is necessary for the metastable trapping states to exist and for the energy of these states relative to the valence band to lie precisely in the optical range. The existence of these depends, in the final analysis, on such parameters as the crystal structure and the type of imperfection which allows the state to remain metastable allowing the electron to exist indefinitely in such a state until it radiates its energy.

There are different types of luminescence. There is phosphorescence and fluorescence depending on whether the radiation is emitted immediately after the electron is exited into the upper state or whether there is a time lag. Be that as it may, the scope of potential applications in this area is very wide, particularly in automotive engineering where color effects as well as surface finishes can ultimately be conceived of as arising from this sort of an effect.

An important development just emerging from the industrial laboratories is the phenomenon of electroluminescence. In brief, electroluminescence is light emission from phosphor powders embedded in an insulator and excited by an a-c field. As late as 1950 the light produced through electroluminescence was so weak that it could be seen only in a darkened room; the efficiency of energy conversion to light was also distressingly low.

Progress, however, has been tremendous, for today the brightness is beginning to match fluorescent

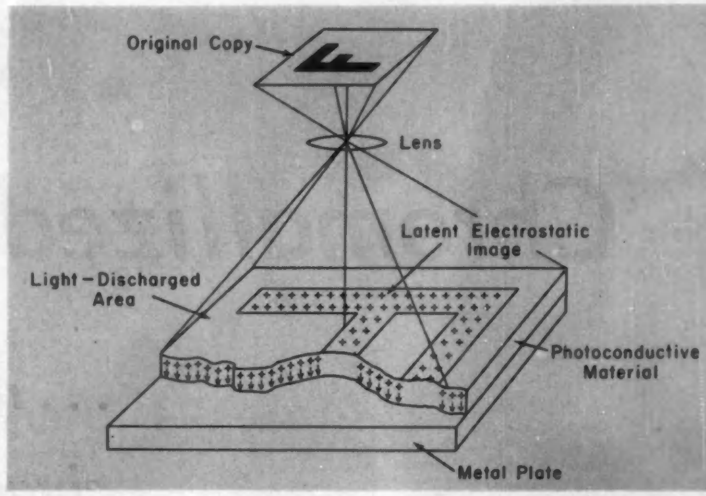


Fig. 6 — Principle of xerography. Charge can leak off the surface through the photoconducting material to the grounded plate wherever light strikes.

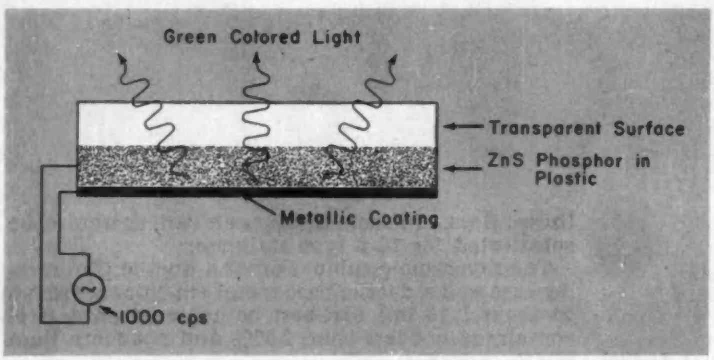


Fig. 7 — The principles of the electroluminescence cell.

lights and the efficiency has been increased to about 9 lumens per watt compared to 16 lumens per watt for an incandescent lamp.

Electroluminescence provides the first large area source of light, produces an even glare-free light, and can be made in practically any size or shape. By the proper choice of phosphors, a wide variety of colors can be produced including blue, green, yellow, red, and when properly mixed, white light.

A simple electroluminescent cell is shown in Fig. 7 and consists of a phosphor powder, usually ZnS, embedded in a clear plastic and connected to two electrodes. So the cell may operate at low voltages and still provide fields of the order of 100,000 volts per in. an extremely thin layer of phosphor-insulator is necessary.

The basic mechanism of electroluminescence is only qualitatively understood and we shall resort to the band theory with impurity or luminescence centers present for a simplified discussion of this interesting phenomenon. In electroluminescence the strong applied field provides the energy source to raise electrons into the conduction band. These electrons are accelerated by the field, collide with luminescent centers freeing other electrons which in turn are accelerated, and so on. Light emission occurs when the direction of the field reverses so that the electrons that originally occupied luminescent centers may return to the now empty centers and recombine with them to produce light.

When the frequency of the applied voltage is varied some phosphors emit a different color. As the frequency is increased the color shift is always toward the shorter wavelengths. Brightness of the cell is affected by frequency and also by voltage changes. Brightnesses of the order of 2000 foot-lamberts have been attained with a green phosphor cell operating at 600 v rms and a frequency of 20,000 cps. Unfortunately, the efficiency of present cells is low at these high brightnesses. Research is underway to increase efficiency, brightness, and color ranges.

The Future

There can be no doubt that major improvements of the known properties of existing materials can be anticipated. But what captures the imagination of those who wish to project their creative processes into the future is the anticipation of radically new properties and revolutionary materials. These are not just improvements in existing properties (a truly worthwhile objective in itself). These are properties yet to be discovered—perhaps in materials yet to be synthesized—conceived in man's understanding of the mechanics and dynamics of the elementary particles which make up the solid.

To Order Paper No. 23B . . .
. . . on which this article is based, turn to page 5.

Chromallized Steel . . .

. . . resists rusting, wear, abrasion, and oxidation.

Based on paper by

Richard P. Seelig

Chromalloy Corp.

CHROMALLIZING enables ordinary iron and steel to resist rusting like stainless steel, wear and abrasion like carbide, and oxidation like high alloy materials.

The Chromalloy process is a method of diffusing chromium (and other elements) into the surface of metal. As the chromium diffuses into the base metal it combines with the elements therein to form an alloy case which is an integral part of the base metal, but with the properties of the new alloy. Unlike superficial coatings, the case won't peel, spall, chip, or flake off. All surfaces, including inside diameters and roots of threads, are penetrated.

The metal parts are packed with a chromium-containing powder compound and placed into a sealed retort, heated to elevated temperature for the required length of time, and then slowly cooled in the retort. The composition of the compound, the temperature, and the time may be varied to produce cases of different depth and properties. The choice of base metal also affects the properties of the case.

When parts made of low carbon steel (SAE 1010) are Chromallized, the case consists of an iron-chromium alloy similar to the ferritic stainless steels — such as type 430 (Fig. 1). The case is ductile, and the part can be bent, formed, and rolled, with considerable amounts of reduction, without damage. Such parts have the corrosion and oxidation resistance of high chromium stainless steels. The Chromallized low carbon steel, however, provides ease of fabrication and weldability which is superior to these alloys. In some instances it can, therefore, be substituted for 18-8 type stainless.

The favorable combination of a ductile Chromalloy case and a ductile base metal (in thicknesses up to about 1/16 in.) can best be achieved on a steel containing not less than 0.06% and not more than 0.10% carbon.

When parts made of higher carbon steels are Chromallized, the case consists of chromium carbides. This case is extremely hard (up to 2200 VPN) and exhibits wear and abrasion resistance similar to tungsten carbide surfaces. Since the base steel becomes annealed during Chromallizing, subsequent heat treatment of the part may be necessary. This will not affect the case.

Stainless steels, nickel or cobalt base alloys, tungsten, molybdenum, and other metals can be Chromallized to provide protection from oxidation and erosion at very high temperatures — up to 3000 F.

Chromalloy Applications—Heat Resistance

One type of electric heating element consists of a Nichrome wire protected by a metal sheath or casing, usually a round or rectangular tube (Fig. 2). Between the wire and the outside casing there is an insulating material (magnesia powder). This type of heating element is used for sheath temperatures up to 1500 F.

Chromallized mild steel (SAE 1010) tubing or sheet can be substituted for stainless steel or high nickel alloys at substantial savings in cost. Where the design calls for rectangular tubing, Chromallized steel offers the additional advantage of availability. Rectangular tubing is not readily available in stainless steel.

One type of electric soldering iron is made with a resistance wire element wrapped around a metal

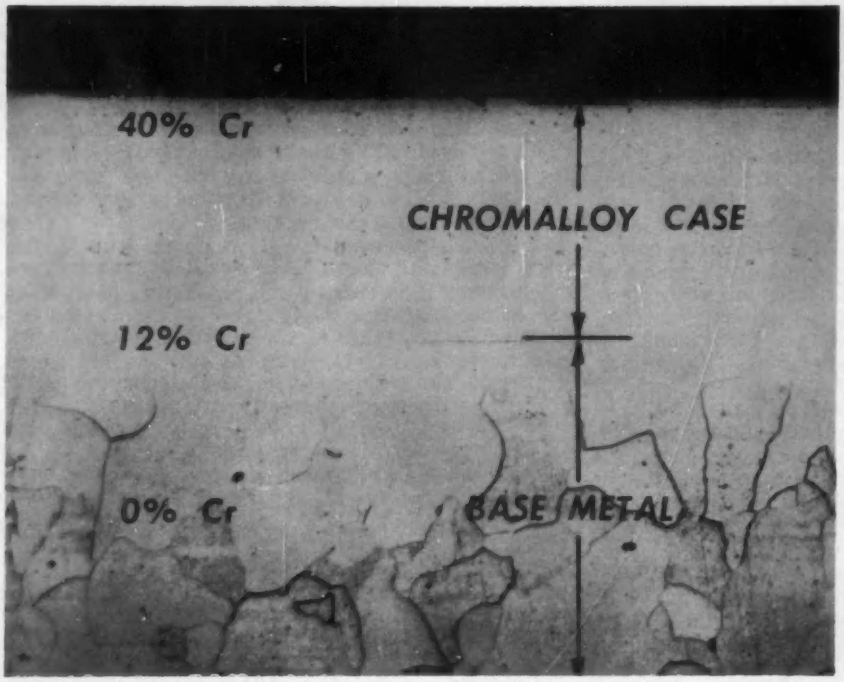


Fig. 1—Chromallized low carbon steel. The case consists of an iron-chromium alloy similar to the ferritic stainless steels

core. This core may reach temperatures of 1000 F or more, depending upon the design. Cores are usually made of steel for the cheaper irons and of bronze in the irons for industrial use. Steel oxidizes rapidly and bronze loses strength at high temperatures, causing the tip to stick so that it can't be replaced. Stainless steel is unsatisfactory because of its much lower heat conductivity and its high cost.

Chromallized free-machining steel has successfully replaced bronze cores for even the highest temperature service. The steel has about the same heat conductivity as the bronze and it machines almost as easily. It is considerably less expensive.

The broilers of some gas cooking ranges are designed with expanded metal radiants. The expanded metal is heated by the gas flame to a red heat (up to 1500 F) and, as the name implies, radiates heat to the food being cooked. Stainless steel expanded metal was formerly used because of its oxidation (scaling) resistance. Chromallized mild steel provides the same scaling resistance and costs less. In addition, mild steel has better heat conductivity than stainless steel. Thus, Chromallized steel radiants heat up quicker and provide a more uniform temperature.

Although any grade of steel can be Chromallized, SAE 1010 steel is recommended where the radiant is to be bent or formed after Chromallizing. Other steels do not form a sufficiently ductile case and core. For maximum ductility the section thickness of the metal should not exceed 0.030 in.

Spark plug electrodes are made of a high alloy wire to resist oxidation. Ordinary mild steel electrodes have been tested in spark plugs in test cars and so far are operating as well as the high alloy spark plugs. The writer's own car has been operating on spark plugs with Chromallized center electrodes for about 8000 miles with excellent results.

Gas turbine vanes and blades require high hot strength as well as resistance to oxidation and erosion. Certain materials which have good high temperature strength but insufficient oxidation resistance have been Chromallized to protect them at temperatures in the neighborhood of 2000 F. Experimental work is now in progress to improve these special alloy cases. This work is expected to help raise the present temperature limitation in the operation of aircraft gas turbines.

Development work now under way indicates that Chromallized exhaust valves may eliminate the need for sodium filled valves in truck engines. Here, it is necesary to provide the alloy with greater heat and corrosion resistance at the surface. Three different alloy diffusion processes are currently under study for this application.

Wear Resistance

Wherever machine parts are subject to metal-to-metal sliding friction, the life of the parts can be increased by Chromallizing. A manufacturer of zippers was able to feed 965,000 parts through Chromallized locating plates compared to 279,000 parts with ordinary hardened tool steel. Similar results were obtained with guides and feeds in can-making machinery. Chromallized forming dies for automobile trim lasted 100,000 operations compared to 3000 operations for the conventional die material.

Pistons in a vertical pump, generating pressures up to 2200 psi were scoring and causing leakage after about 600 hr of service. Chromallized carbon steel pistons lasted seven times as long and were less expensive than those made of the stainless steel formerly used.

A flexible cable push-pull control for an aircraft engine contained two telescoping tubes which operated at 1000 F. Type 321 stainless steel tubes failed

Chromallized Steel . . .

continued

by seizing at 300 cycles. Chromallized 4130 steel tubes operated for 100,000 cycles with no failure. This is now specified as standard equipment for one of the more powerful jet engines being produced.

Hardened steel links for portable power chain saws are subject to wear from steel pins connecting the links and to abrasion from sand and soil. One manufacturer of chain saws reported that in cutting trees below grade, Chromallized SAE 1070 steel links lasted two to three times as long as hard chromium plated links.

A cigarette machine manufacturer tested Chromallized D-2 tool steel parts against the heat treated tool steel formerly used. The parts were subject to wear by contact with rapidly moving paper and tobacco. Regular heat treated parts wore out after producing 15 million cigarettes. The Chromallized parts produced 73 million cigarettes.

A shoe machinery manufacturer tested Chromallized cutters made from carburized low carbon steel (SAE 1018) and compared them to the high speed steel (T-1) formerly used. The cutters were subject to wear from the shoe leather soles being shaped to the correct dimensions. The Chromallized cutters, although less expensive, outlasted the high speed steel cutters from 2 to 7 times. Making the cutters from low carbon steel cut material costs and provided large savings in machinability.

Chromallized spark wheels are being used in many cigarette lighters. They last 3 to 5 times as long as wheels formerly used, and the quality of the spark produced is better.

Corrosion Resistance

A manufacturer of aircraft relays had difficulty meeting corrosion resistance requirements without affecting the magnetic properties of relay parts. A particular armature had a high rate of rejects because the thickness of the electroplated coating used, being nonmagnetic, had to be carefully controlled within very close tolerances. Too thin a coating would give insufficient corrosion protection, while too thick a coating would unbalance the relay because of the magnetic properties required.

Chromallized Armco ingot iron armatures solved the problem. Its corrosion resistance met the exacting specifications, and since the Chromalloy case is magnetic, it did not interfere with the magnetic properties desired. Furthermore, the customer was able to eliminate the "magnetic anneal" formerly required because the Chromalloy process anneals the parts during the Chromallizing.

A manufacturer of steam traps had complaints of the trap body eroding due to the action of wet steam. He tested trap bodies machined from type 410 stainless steel and found they were satisfactory except for an increase in cost.

Chromallized ordinary steel steam trap bodies were tested and found to be equal to the stainless steel bodies in corrosion and erosion resistance, at a considerable savings compared to stainless steel.

An appliance manufacturer had a problem with a solenoid valve. The valve stem was machined from type 430 stainless steel, and operated against a rubber valve seat. Since the stem was operated by a solenoid, it was the armature of a magnetic circuit. The stainless steel was corrosion resistant in ordinary service, but when the machines were stored for several months, the stems corroded where they were in contact with the seat.

New armatures were made as iron powder sinterings, Chromallized, and then impregnated with a resin to seal the pores underneath the Chromalloy case. These parts were tested for corrosion and found to be better than the solid stainless steel. Also, the valve operated better because of the superior magnetic properties of the ordinary iron core. Cost savings were realized by replacing the machined bar with a molded metal powder sintering.

Cost of Chromallizing

Chromallizing costs are determined by the volume of the part and the quantity to be processed at one time. They are controlled also by the amount of chromium taken up by the steel, the labor required to prepare a run, the fuel necessary to operate the furnace, and the upkeep of the retorts. Thus, the cost of each item has to be considered on its own merits and calculations prepared for each application. As a general guide the following comments may be helpful:

In many applications a Chromallized part can favorably compete with one made of stainless steel. However, if the part has a high volume-to-weight ratio the stainless steel part may be cheaper. Usually, a larger savings can be realized in applications where longer life reduces maintenance and downtime.

An ideal application for Chromallizing is one in which the base metal, selected for certain required properties, does not have good enough surface properties, that is, resistance to wear, rust, or scaling.

In general, Chromallizing is more expensive than the conventional heat treating methods (quench and temper, carbonitriding, and such). It is also more expensive than simple barrel electroplating. However, for certain parts that have to be specially handled and racked, Chromallizing may be less expensive.

Chromallizing is less expensive than most hard facing processes, such as coating with tungsten carbide. Chromallized parts do not require grinding, resulting in further savings.

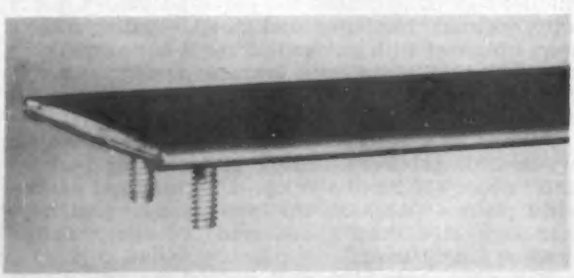
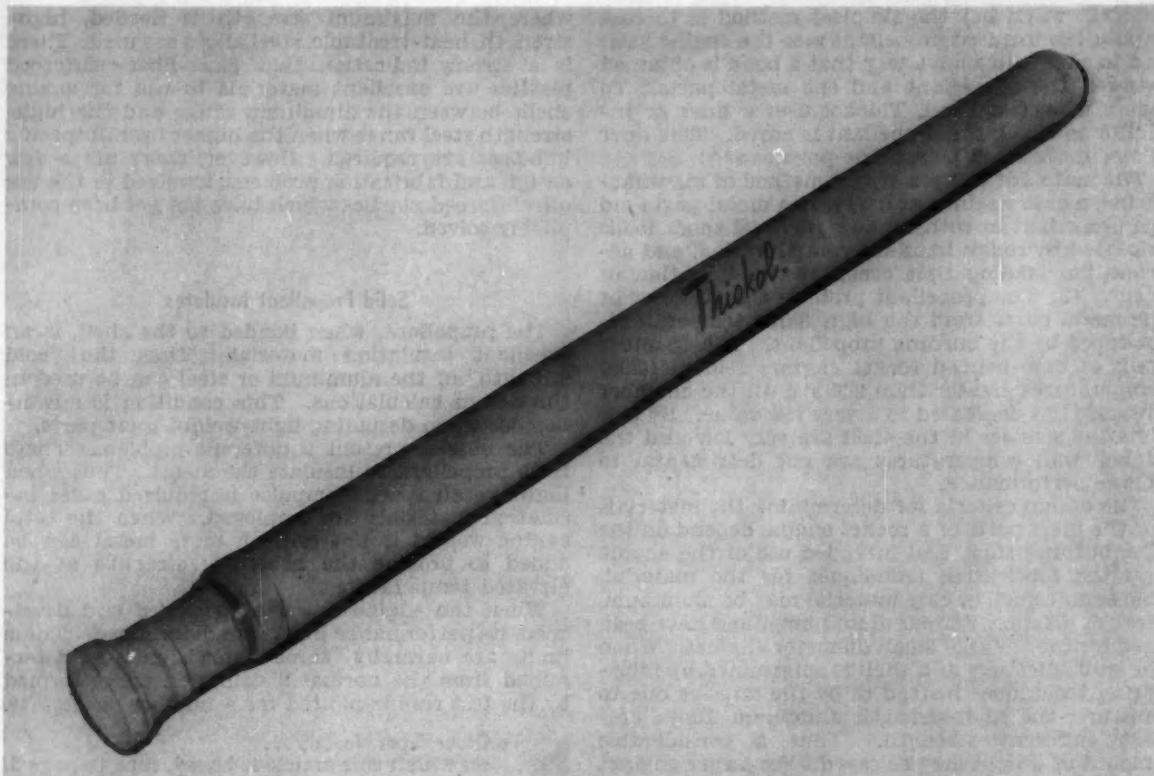


Fig. 2—Protective casing for electric heating element can be made of Chromallized mild steel at substantial savings in cost over stainless steel or high nickel alloys

To Order Paper No. 30B . . .
. . . on which this article is based, turn to page 5.



CAJUN ROCKET ENGINE has been used in high-altitude research programs. In conjunction with a Nike booster, altitudes over 100 miles have been explored. This engine is the first off-the-shelf rocket engine in the history of rocketry.

Abridgment of an **SAE Metropolitan Section Paper**

A Solid-Propellant Rocket Engine . . .

. . . is composed of the composite fuel and oxidizer, the case and nozzle assembly, and an igniter or initiator assembly.

Excerpts from paper by

Charles R. Voris

Thiokol Chemical Corp.

SOLID-propellant rocket engines, when properly designed, will withstand exposure to temperatures of –65 to 165 F for relatively long periods of time and still operate within standard specifications at high, low, or standard ambient temperatures. They will withstand vibration, rain, humidity, and salt spray tests as prescribed by the military specifications.

Usually shipped as a complete assembly with the exception of the igniter, the engine is installed onto or into the missile, the igniter is inserted, connections are made to the ignition circuit, and the engine is ready to use. This is why solid-propellant rocket engines are rugged, easily used powerplants.

A composite solid propellant is composed basically of a fuel and a crystalline oxidizer with the necessary additives to promote or retard burning rate and curing. The fuel is sometimes referred to as the binder for the oxidizer and additives. Thiokol propellants use as the fuel certain special polysulfide polymers manufactured by Thiokol Chemical Corp.

A case-bonded propellant is one that is bonded directly to the engine shell and other parts of the rocket engine. This condition can be obtained in

different ways, but the simplest method is to cast or pour the uncured propellant into the engine shell and to cure it in such a way that a bond is obtained between the propellant and the metal parts. To insure a perfect bond, Thiokol uses a liner or inhibitor to which the propellant is cured. This liner is also made from polysulfide polymers.

The main advantages of this method of manufacturing rocket engines are: (1) The metal parts aid the propellant in withstanding physical shock loads imparted by rough handling and vibration, and acceleration loading that occur at the initiation of flight. (2) The propellant protects the majority of the metal parts from the high flame temperatures produced by the burning propellant. The chamber walls of case-bonded rocket engines seldom reach temperatures greater than 200 F until the chamber pressure has decreased to a very low value. By this time the stresses in the shell are very low and the higher wall temperatures are not detrimental to engine performance.

The design criteria for determining the materials for the inert parts of a rocket engine depend on the size, burning time, and intended use of the engine and the fabrication techniques for the material. The engine shell or case material may be aluminum, steel, or plastic. Various aluminum alloys have been used for the shells of small diameter engines. When the wall thickness of a shell is determined by fabricating techniques instead of by the stresses due to pressure, the high-strength aluminum alloys present sufficient strength. Thus a considerable amount of weight may be saved. For larger engines where the maximum strength is needed, high-strength, heat-treatable, steel alloys are used. There is a strong indication that glass-fiber-reinforced plastics are excellent materials to use for engine shells between the aluminum range and the high-strength steel range when the higher overall specific impulses are required. However, there are a few design and fabrication problems involved in the use of reinforced plastics which have not yet been completely solved.

Solid Propellant Insulates

The propellant, when bonded to the shell, is an excellent insulation material. Thus the "cold strength" of the aluminum or steel can be used in the design calculations. This condition is advantageous when designing light-weight inert parts.

The nozzles present a different problem. There is no propellant to insulate the metal. Thus when high overall specific impulse is required other insulation materials are employed. When the total engine weight is not critical, more metal can be added to provide the necessary strength at the elevated temperatures.

When the engine has been designed and developed, its performance limits are determined. These limits are normally "three sigma" limits as determined from the normal distribution curve formed by the test results plotted for a number of engines.

To Order Paper No. S85 . . .
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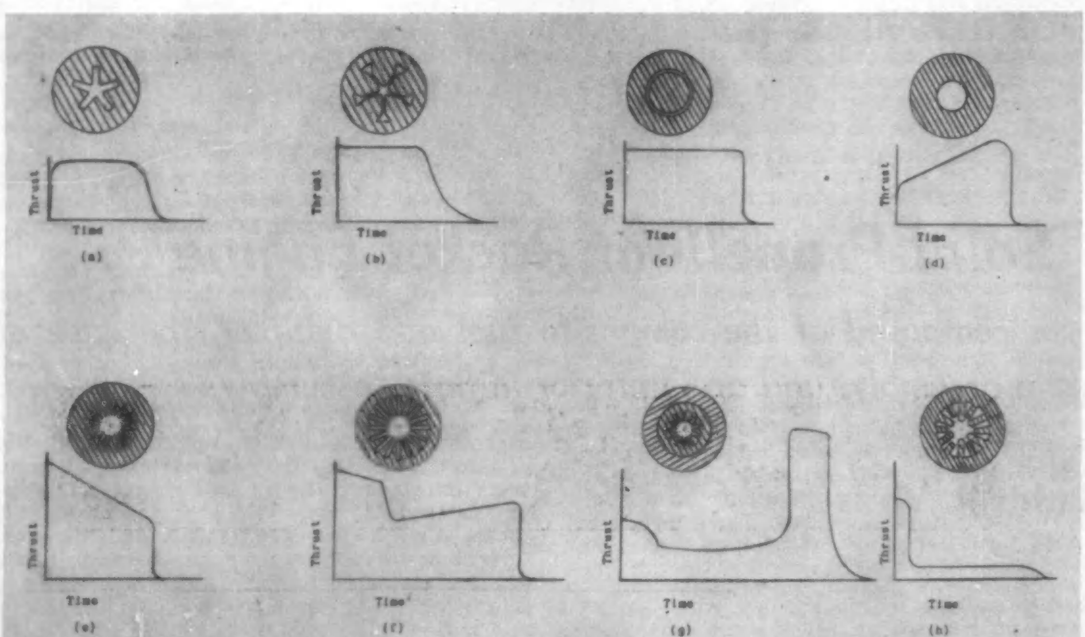


PROPELLANT CHARGE CONFIGURATION determines thrust program. Star and web configurations a and b are the more common since these designs with slight variations will give either a neutral, slightly progressive, or slightly degressive program as required. These designs are easy to manufacture, and they operate well at relatively low temperatures. The two-level thrust program shown in h is used in drone and gas generator work where a high impulse is required to initiate the movement of the driven object and the motion is then to be sustained for a relatively long time.

Lowering Cars . . .

. . . poses problem of driveshaft tunnel, but let's avoid dogma of all-front-drive or all-any-other-substitute design.

Based on paper by

Peter Kyropoulos

General Motors Corp.

ASIDE from the Lancia Aurelia modification of conventional design, which combines the transmission with the rear end, alternative designs to solve the floor tunnel problem group powerplant and transmission at the front or rear end.

The Lancia Aurelia modification eliminates the hump in the front compartment and since the shaft transmits only engine torque and can be smaller, the tunnel is reduced in width if not in height. Although transmissions are more compact, they still take up space and in this instance that space comes out of the trunk. If the rear deck is lowered in addition, both space and useful geometry are limited. Moreover, this configuration severely limits the station wagon since clearance between floor and ceiling becomes too shallow.

Other alternatives are to concentrate the powerplant and transmission in front or in the rear. The pros and cons of these designs have been discussed with more emotion than common sense. Neither arrangement poses insurmountable problems, but neither can be cobbled together from existing conventional components. Hence, considerable development work is necessary before either type can be built.

The directional instability of rear-engine cars can be removed readily by proper suspension. Either configuration provides clear floor space and allows lowering of the passenger compartment. Both provide a compact power package, which could be built as a subassembly and installed and removed as a whole. Combining engine, transmission, differential, and rear axles into one package represents a great concentration of mass, but I believe this can be turned to advantage by reducing repetitious components, duplication of function (housings), and the like. Extensive use of light alloys is indicated and some components already show the process of miniaturization.

Pros and Cons of Rear-Engine Drive

Examination of the possibilities of rear-engine drives reveals:

1. Driving wheels are not steered.
2. Placing of powerplant weight over driving wheels improves traction.
3. Controls for engine and transmission have to be brought forward. This is particularly awkward with manual transmissions.
4. If the battery is located forward to improve weight distribution, the heavy starter lead must traverse the whole car.
5. Spare wheel and luggage must be carried in front. This space does not provide a very favorable geometry for the purpose, since it must house front suspension, steering, brake mechanism, and possibly fuel tank.
6. Location of powerplant prevents use of the same chassis for a station wagon.
7. There is considerable apprehension about placing the fuel tank in the front of the car. This is not realistic. The energy stored in a gallon of gasoline is of the order of 160,000 Btu or 3.2×10^6 Btu for a 20-gal tank. If this energy is released accidentally it does not much matter where in the car it happens. The probability of fire in an accident, I believe, is a result of the presence rather than the location of the fuel.

Pros and Cons of Front-Wheel Drive

1. Driving wheels must be steered. This poses mechanical design problems, especially for larger power and torque. It works well for small powerplants and there is no reason why it cannot be worked out. We haven't tried very hard. At this point it is customary to quote a long series of unhappy experiences with Cord front-drive cars. This is not germaine to the subject. We might also reason that tires used to go flat at an average of every 500 miles, hence should not be considered feasible for present cars. We improved the tires rather than return to the solid wheel.
2. Engine and transmission controls are close to the components they control.
3. Reduced traction on a grade need not be serious if the powerplant is placed sufficiently far forward.
4. Ample space can be made available behind the rear passenger for fuel tank, spare wheel (if needed at all), and luggage.
5. The rear suspension can be relatively simple and allows room for a station wagon body.

To have enumerated these items classed as advantages and disadvantages would have resulted in oversimplification and arguments over relative merits. An optimum solution has to take into account considerations besides engineering and styling which are not under discussion.

Agreed that every dogma has its day, nevertheless we do not want to develop any automotive dogmas, such as all front drive or none, or whatever idea you may want to substitute.

To Order Paper No. 4B . . .
. . . on which this article is based, turn to page 5.

Pressurized Water Reactor . . .

. . . fuel costs depend mainly on core fabrication costs and the value of the recovered plutonium.

E. D. Reeves Esso Research & Engineering Co.

(Based on report to the SAE Nuclear Energy Advisory Committee)

CORE fabrication costs and the value of the recovered plutonium may be the key to fuel costs for the pressurized water reactor fueled with UO_2 in a stainless-steel core. These two factors are the main reasons for the range in anticipated costs of 2.3–6.4 mils per kw-hr developed in an analysis presented at a recent meeting of the American Nuclear Society New York Section.

Core fabrication costs were estimated as high as $2 million for a single initial core and as low as $300,000 for a production line operation running at full capacity.

The value of the recovered plutonium will be $30 per gram in 1963, according to the present AEC schedule, but it is expected to decline eventually to $12 per gram, based on its value for nuclear fuel. The minimum estimate of 2.3 mils per kw-hr is

Table 1—Nuclear Fuel Cycle Costs (Basis: Complete cycle on one core)

		Costs, $ million		Comments
		Max	Min	
3% UF_6 Obtained from AEC	8.33	—	—	22,220 kg at $375/kg
Conversion of UF_6 to UO_2		0.67	0.22	Range of $10–$30/kg
Losses at 3% U_{235} Concentration	0.08	—	—	1% at $375/kg
Fuel Element Fabrication		2.00	0.30	$90/kg for initial core; about $14/kg for later production line operation
Shipping Spent Core		0.22	0.16	2000-mile round trip (East Coast to Idaho)
Chemical Processing		0.46	0.29	AEC schedule (1 ton/day) and similar plant scaled to 10 ton/day level
Conversion of Nitrate to UF_6		0.28	0.07	Range of $3–$13/kg
Losses at 2% U_{235} Concentration	0.05	—	—	1% at $220/kg
2% UF_6 Returned to AEC	4.73	—	—	21,480 kg at $220/kg
Burnup + Losses		3.60	3.60	Difference between off-take and return value
Use Charge		0.83	0.83	4% on initial inventory Total cycle = 2 × reactor residence time
Total		8.06	5.47	
		Credits, $ million		
		Max	Min	
Pu Recovered		1.06	2.64	88 kg at $30/gram (1963 schedule) and $12/gram (eventual fuel value)
Less Nitrate Converted to Pu Metal		0.21	0.09	Range $1–$2.40/gram
Net		0.85	2.55	
		Net Fuel Cycle Cost		
		Max	Min	
$ Million/Core		7.21	2.92	
¢/Million Btu Generated		47.0	19.0	
Mils/Kw-Hr Electricity		6.4	2.3	[illegible] % efficiency
		Approximate Effect of Fuel Element Life on Fuel Cycle Cost,[a] mils/kw-hr of electricity		
		Max	Min	
5000 Mwd/Ton		8.0	2.7	
7500 Mwd/Ton[b]		6.4	2.3	
10,000 Mwd/Ton		5.6	2.1	
20,000 Mwd/Ton		4.4	1.8	

[a] Basis: Net burnup and use charges are independent of element life, other charges are inversely proportional. [b] Corresponds to this example.

raised to 3.5 mils per kw-hr if the low figure for plutonium value is applied to this case.

A detailed analysis of how the fuel costs were determined for the pressurized water reactor fueled with UO_2 in a stainless-steel core is given in Table 1. The additional data assumed for this case are:

Heat output—500 mw
Saturated steam—500 psia
UO_2 in core—25,000 kg
Enrichment at start—3% U_{235}
Enrichment at end—2% U_{235}
Plutonium production—0.4 gram per gram U_{235} destroyed

The core was estimated to generate 15.35×16 million Btu, with 16 months life at 80% operating factor. Complete replacement at the end of the core's useful life was postulated.

The estimates in the table are based on a fuel element life of 7500 megawatt-days per ton. This is indicated to be feasible by small-scale irradiations of UO_2, but has not yet been demonstrated on complete fuel elements. Since this is the only factor over which the nuclear engineer has some control, the approximate effect of irradiation life on fuel cost for power generation is also indicated in the table.

Other interesting points revealed by the table are the following:

1. Fuel element fabrication costs (at approximately $16 per kw of electricity even for an initial core) do not represent a major factor in the total investment for a nuclear power plant (about $300 per kw of electricity). Presumably, development charges for a new type of element are not included in the estimated fabrication cost.

2. Fuel element fabrication may initially represent about 25% of the expense associated with a complete fuel cycle. It may decline eventually to as little as 5%.

3. Factors under Government control, such as the cost schedule for U_{235} of various degrees of enrichment, and the value assigned to recovered plutonium are extremely significant in determining the net cost of the fuel cycle.

4. The present outlook for net fuel cycle cost (in terms of ¢ per million Btu, when coupled with an industrially attractive level of return on the required plant investment, does not indicate a major incentive for the development of process heating from nuclear sources.

6 Design Changes for the "Truck Driver's Office"

Based on paper by **Julius Gaussoin**, Silver Eagle Co.

WHEN truck drivers speak their minds they find much to criticize in the comfort of cabs and the placing of controls for safe, easy handling. Here are six design alterations for a happier day at the wheel, gleaned from answers to a questionnaire submitted by the author to his driver organization:

1. Dimmer Switch.

The "punch-punch" floor switch is out-of-date. With a simple 3-post toggle switch you can feel or see the position of the switch and be sure of your beam position. Convenient positions are the gearshift lever or the steering post. An easy to reach position on the dash is even better.

2. Brake Pedal.

The pedal should be wide and low, not narrow and long. It should be comfortable under the left foot and wide enough so that the left foot can apply the brake, then be left on the brake pedal while the right foot is brought over and placed on it. This permits continuing brake application, yet allows the driver to take his left foot from the brake pedal to depress the clutch pedal. This is of real safety importance.

3. Switch versus Gage Location.

Switches should be convenient and definite in position. The tachometer should be most easily read. Other gages should be located for reasonable position and readability, standardized as recommended by the Instrument Panel Subcommittee. The dash should be simple, with space for additional gages and instruments.

4. Driver's Position.

A one-driver truck, or truck driven by several drivers, needs an excellent cushion. Cellular foam rubber seems to fit better after long use. The chair seat should be adjustable fore and aft, not necessarily electrically operated. Its height must be adjustable. The back of the seat needs real attention and the inclination should be adjustable. Experience can be gleaned from foreign car design.

5. Windshield Wipers and Washers.

One-piece windshields require consideration of overlapping the arcs of the wiper blades. Vertical wipers moving back and forth laterally do the best job in both rain and snow. Let's think of putting water for windshield washers at the top of the windshield instead of squirting it at the bottom, with resultant poor coverage.

6. Turn Signals—Lens Color.

White turn signals in front are not very demanding of attention when the weather is bad, or in competition with headlights. Red for the rear must compete with red tail and stop lights. Why not amber or yellow for both front and rear? It can be considered optionally permitted and the laws can be changed or modified.

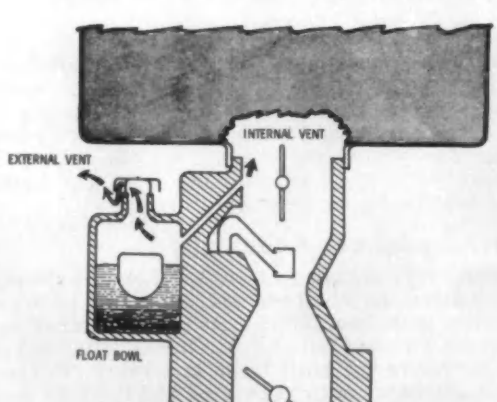
To Order Paper No. 19C ...
... on which this article is based, turn to page 5.

Why Carburetor Vents Are Needed

CARBURETORS are provided with vents because the increase in pressure due to the vaporization of the gasoline in the float bowl, as the carburetor is warmed up in service, would be far greater than the pressure used to meter gasoline into the engine. Consequently, a carburetor adjusted to meter properly at one temperature would not meter correctly at another.

Drilling a hole in the top of the bowl cover (external vent), as shown in the illustration, thus relieving the pressure in the carburetor bowl, solves this problem but introduces others. During hot-weather operation the gasoline vapor finds its way into the passenger compartment and the driver notices "gasoline smell." A loss in economy, depending on how hot the bowl becomes, will result. Of course, the vapor also contributes to air pollution.

If, instead, the vapor is channeled to the engine air inlet, as shown by the internal vent in the illustration, the odor problem is solved, but hot-starting difficulty will probably occur. This, as the name implies, is a delay in starting an engine due to an accumulation of fuel vapor in the intake manifold, causing an overrich mixture. Another problem is that, with the engine running, the internally vented vapor represents fuel added to the engine in excess of that required for optimum engine operation, and stalling or engine roughness may be encountered at idle.



Carburetor

. . . isn't easy to eliminate. But a recent study produced some data that may prove helpful in resolving the problem.

Based on paper by

J. T. Wentworth

Research Staff, General Motors Corp.

NEITHER external nor internal vents present an ideal solution to the carburetor vapor loss problem. So, the designer has to look for a compromise to minimize those phases of the problem he considers most important.

Investigations of carburetor evaporation losses in five cars points up this conclusion from a number of different angles. (Each of the five cars had a different design of internal or external vent on its carburetor.

What the Studies Showed

The studies showed three main things:

1. Fuel volatility has a pronounced effect on carburetor loss, as does carburetor bowl temperature. Slow-speed driving in city traffic tends to increase bowl temperature and, consequently, vapor loss. (Although Reid vapor pressure was used to characterize fuel volatility, several inconsistencies in the data are interpreted as indications that Reid vapor pressure was not an ideal parameter of carburetor vent loss.)

2. During the period immediately after stopping an engine it was found that additional vapor was given off. This loss was measured on one car and most of the loss, about 0.018 lb, occurred in the first 30 min after shutdown.

3. The vented vapors were composed primarily of low-boiling hydrocarbons having 4, 5, or 6 carbon atoms per molecule. It was concluded that the kinds of hydrocarbons vented were determined by

Vapor Loss

the hydrocarbons of this boiling range in the gasoline.

Fuel Volatility and Bowl Temperature

The carburetor vent loss for car A (see Table I) is shown in Fig. 1. The loss is expressed as per cent by weight of the fuel used on the trip and is plotted against average bowl temperature. Results for five different test fuels are shown and identified by their Reid vapor pressures.

The 6.0- and 7.0-psi Rvp fuels gave no loss at bowl temperatures up to 122 F, while losses were obtained with the three higher volatility fuels. The vent loss is clearly influenced by bowl temperature and volatility, but the effect of fuel volatility above 8.5 psi Rvp is somewhat obscured by the fact that the 9.6- and 10.1-psi Rvp fuels are reversed. The most probable explanation for this is that Reid vapor pressure is not an ideal indicator of evaporation loss. The 10.1-psi Rvp fuel was handled differently than the other fuels. Although it ended up as a 10.1-psi fuel, its distillation curve is markedly different from that of the 9.6-psi Rvp fuel.

In Fig. 2 is shown the carburetor evaporation loss for car B. The carburetor of car A, it will be noted, had a rather small internal vent. The carburetor on car B, was almost identical to that of car A, except that it had no internal vent.

The tests with car B were all run with essentially the same fuel (9.1–9.3 Rvp) but with different driving conditions. It can be seen that there is very little difference between the losses obtained with car B and the losses obtained with the 9.6-psi fuel in car A, indicating that the internal vent of car A was not effective in removing vapor from the float bowl. It is also apparent that the three driving conditions (20–22 mph average speed in traffic, 25–30 mph constant speed, and 35–40 mph constant speed) gave similar losses.

The results obtained with car C are shown in Fig. 3. Both city-driving and country-driving runs were made with car C. The city- and country-driving runs are coded to show any effect of driving speed. Although the difference in driving speed caused a great difference in bowl temperature, driving speed itself had no effect on carburetor evaporation loss. This is shown by the dovetailing of city- and country-driving points for each fuel.

Car C was the same make as car A and the carburetors were identical. The two cars differed by one year in manufacture but there was very little difference in anything that could conceivably affect carburetor losses. It was expected that the losses for the two cars would be identical and the results shown in Fig. 3 came as a surprise. The losses for car C started at a bowl temperature some 20 F higher than those for car A.

It is possible that some physical difference in cars A and C caused the difference shown by the comparison of Figs. 1 and 3, although this seems unlikely. A variety of things could have been different in the two cars to cause the *bowl temperatures* to

Table 1—Test Cars

Car	Year	Air Conditioner[a]	Carburetor	Carburetor Vent Code[b]
A	1956	no	2 barrel	1
B	1956	no	2 barrel	2
C	1957	no	2 barrel	1
D	1957	yes	4 barrel	3
E	1957	yes	2 barrel	2

[a] The cars equipped with air conditioning were tested with the air conditioning set for maximum cooling. All five cars were equipped with automatic transmissions

[b] 1. Large external vent, always open; internal vent 1/16 in. diameter by approximately ¾ in. long.

2. Large external vent, always open; no internal vent.

3. External vent open at throttle openings from idle to opening of second barrels; large, multiple internal vents.

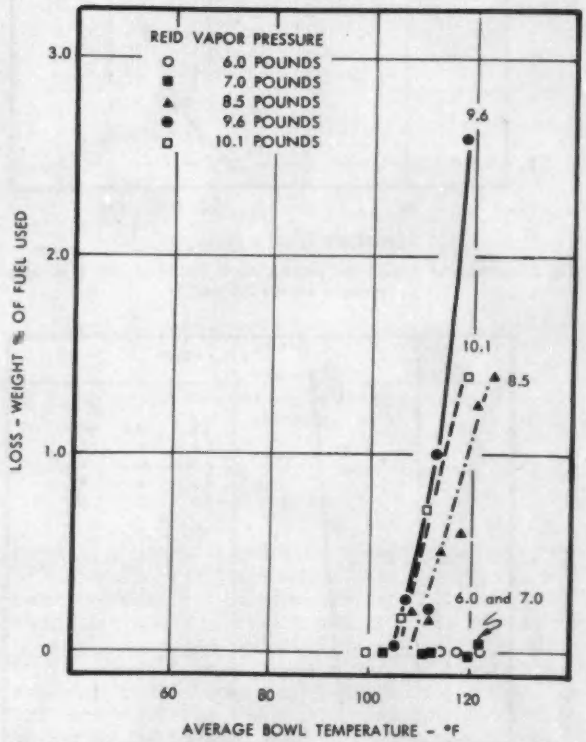


Fig. 1—Carburetor evaporation loss for car A, at average speed of 19-24 mph.

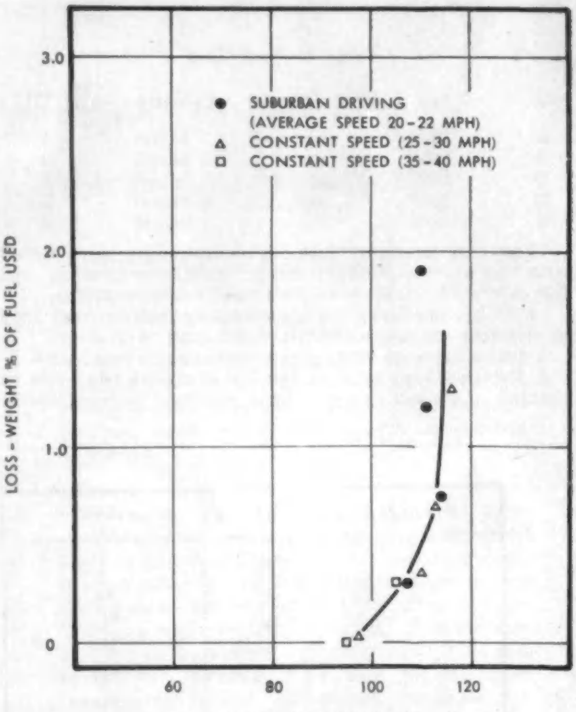


Fig. 2—Carburetor evaporation loss for car B, for fuels with Reid vapor pressure of 9.1-9.3 psi.

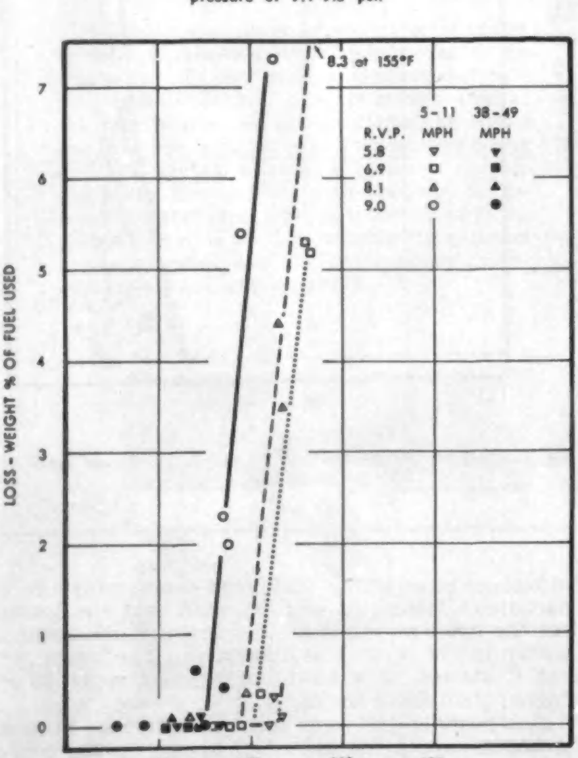


Fig. 3—Carburetor evaporation loss for car C.

Carburetor Vapor Loss

continued

be different if the two cars were subjected to identical conditions of driving, ambient temperature, and so on, but when the results were plotted against bowl *temperature*, it was expected that identical results would be obtained.

By the time the project had progressed to the point represented by the work on car C, the importance of the fuels was more evident. By using one base fuel and modifying it to obtain different volatilities, the embarrassing predicament of reversed lines, as in Fig. 1, was avoided. However, the large discrepancy between the results of cars A and C, which were supposedly identical, cast further doubt on the use of Reid vapor pressure as a parameter of carburetor evaporation loss. It was used simply because nothing better was found.

Car D had many large internal vents, while the single external vent was small and restricted. No results are plotted for this car because there was no loss, even under the most severe conditions. During one city driving run, the bowl temperature reached an average of 172 F, while the radiator was over 240 F and venting steam, and yet there was no loss through the external vent using the 9-psi Rvp fuel!

Results for car E, which had only the external vent, are shown in Fig. 4. Although cars C and E are different makes with different make carburetors, the results are nearly identical. Increased bowl temperatures and fuel volatility caused increasing losses and again there was no effect of driving speed on losses, apart from its effect on bowl temperatures.

With the possible exception of car D, the results obtained on all cars gave the general impression that the carburetor loss was simply a distillation process in which the loss depended on the temperature and volatility of the fuel. While car D appears at first to be an exception, some further tests proved otherwise.

Hot Soak Loss

There is yet another aspect of the carburetor vent loss problem which has been termed "hot soak loss." A great deal of heat is stored in an engine while running and, if the engine is stopped, this heat will

Table 2—Analysis of Vented Vapor (Loss 0.74%)

Carbon Number	%
C_3	2
C_4 (including 1% butene)	44
C_5	33
C_6 (including a possible 3% hexene)	14
C_7	6
Heavier and aromatic	1
Total	100

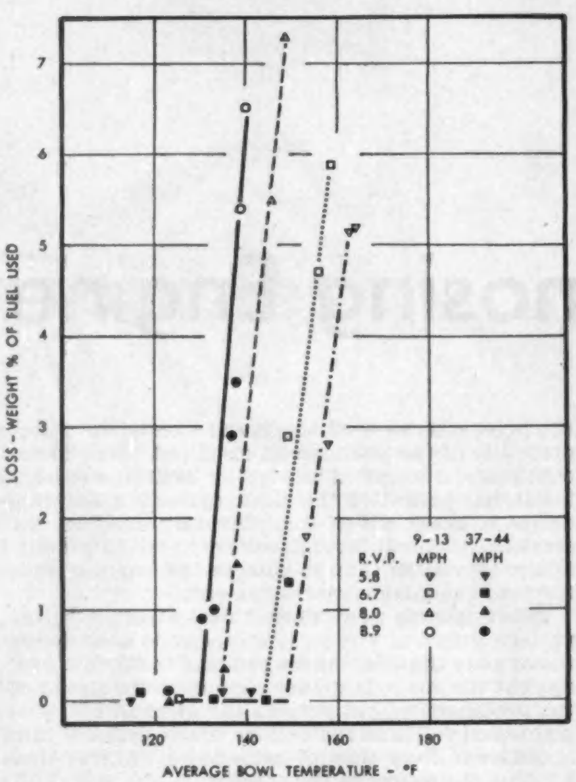


Fig. 4—Carburetor evaporation loss for car E.

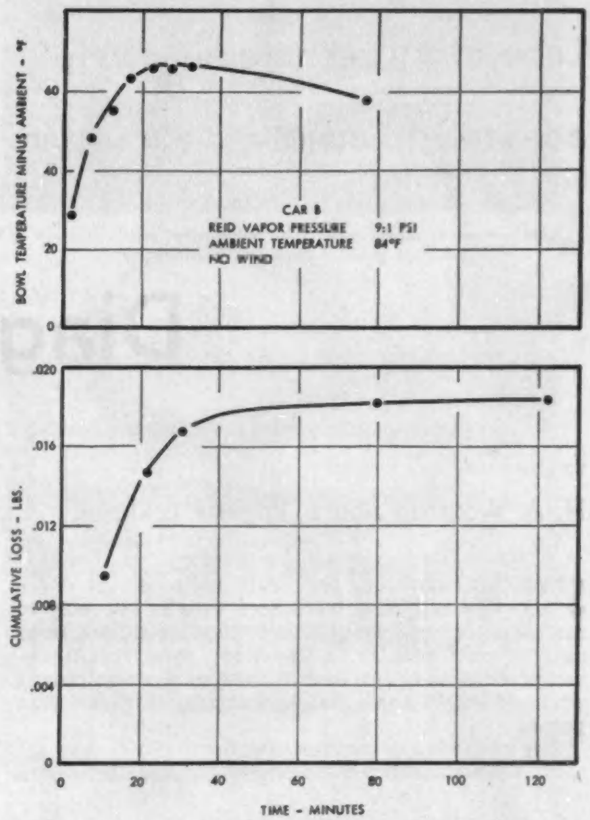


Fig. 5—Hot soak loss. Note that most of loss occurs in first 30 min after shutdown.

warm the carburetor. Temperatures of 60–70 deg above ambient are usual in this kind of service. Fig. 5 shows the temperatures and vent loss obtained from car B during a typical hot soak. The fuel was a 9.1-psi Reid vapor pressure commercial gasoline. The car was warmed up and then parked. Vent loss collection was started when the engine was turned off. This loss must be considered in addition to the losses previously presented because it is a loss occasioned by complete shutdown of the car and the previous tests were made without shutdowns.

It can be seen that most of the hot soak loss occurs as the temperature in the bowl is rising, that is, in the first 30 min. Thereafter the rate of loss is very low. The flat bowl contained 0.15 lb of gasoline, of which 0.018 lb boiled off. Larger bowl capacity, as in a 4-barrel carburetor, would obviously give larger losses. Unfortunately, time was not available to explore hot soak losses further, but preliminary guesses were that it would account for less hydrocarbon emission than that obtained during city driving.

Composition

According to one reference the "vapor from motor gasoline contains hydrocarbons chiefly in the range of isobutane, n-butane, isopentane, n-pentane, and hexane—with the butanes and pentanes as principal components." Only one analysis was made of the condensate collected in the present work. The condensed vapor from a run with car B was analyzed using a gas chromatographic column. A hypodermic needle cooled with dry ice was used to withdraw condensate from the trap and inject it into the column. The anaylsis is shown in Table 2.

The fuel for this test was a premium commercial gasoline. As can be seen in the table, most of the vapor was composed of paraffins with 1–4% olefins and a trace of aromatics. Obviously, the composition of the carburetor vent vapor is determined by the composition of the gasoline in the low boiling range and, if a fuel high in olefins in this range is used, the percentage of olefins in the vapor will increase. It is also obvious that the smaller the amount of low boiling hydrocarbons of *any* type, the smaller will be the vent loss.

To Order Paper No. 12B . . .
. . . on which this article is based, turn to page 5.

Laboratory techniques newly adapted to maintenance use in

Diagnosing Engine

Based on paper by

N. A. Accardo and E. Eugene Ecklund,

Allen B. Du Mont Laboratories, Inc.

SEVERAL laboratory tests valuable to design engineers—would long have been equally valuable to maintenance engineers if only they could have been applied conveniently in the field. Now, recent developments have resulted in inexpensive equipment which can be used conveniently at various field points.

The cathode ray oscilloscope, for instance, has always been considered laboratory rather than field equipment because of the requirements for interpretation of the phenomena displayed. But, in recent years, a so-called "raster" or multiline presentation has permitted this basic dynamic measuring device to break out of the laboratory and into the service station. It is much easier to read this multiline presentation than to observe the complex wave forms of the laboratory instrument.

This relatively new "raster" device results in the pattern shown in Fig. 1 . . . and permits a mechanic to compare the phenomena relating to one cylinder against the rest. It makes secondary the detail of the presentation, but permits the mechanic to pinpoint the portion of the pattern of one cylinder that is different from that of associate cylinders—thus locating the source of the trouble.

And, since the cathode ray tube is a basic *electrical* indicating device, it can directly show ignition performance, too. Ignition phenomena can be viewed by a tune-up mechanic in its dynamic form and the engine checked while it is running.

Transducer devices, designed to change other basic phenomena into electrical energy to permit viewing

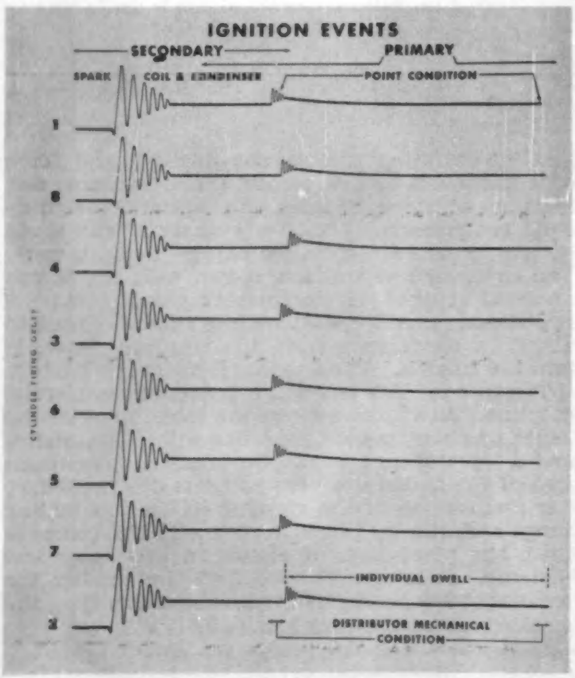


Fig. 1 — Raster or multiline pattern showing characteristics utilized for isolation of trouble by comparison of phenomena in one cylinder against the rest.

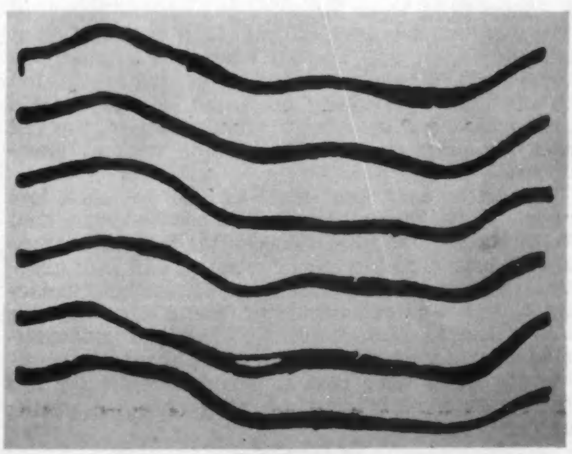


Fig. 2 — Pattern shown by valve testing pickup device when everything is working satisfactorily.

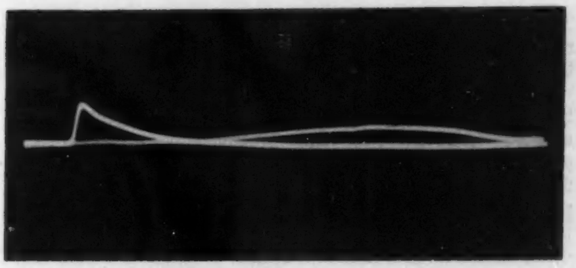


Fig. 4 — Line starts when spark plug fires. Pulse shows top-dead-center position of flywheel. Timing is 5 deg.

Troubles

on the oscilloscope, comprise another type of device which recent development makes available for the service station. That such equipment usually has been cumbersome, fragile, or difficult to use has not made it unacceptable to laboratories, because it did produce otherwise unattainable results. But it was totally unable to produce the "go-no-go" answers necessary for service station use.

But the gap has been bridged by several transducer devices.

One of these, which tests valve pickup, is a pressure-vacuum device, and is no more expensive than a power timing light. It connects to the engine in the same manner as a vacuum gage, and presents information on the oscilloscope screen. It is a magnetic device located inside a closed cylinder.

As the vacuum or pressure of the system under test varies, a diaphragm-type device is caused to move. Fig. 2 shows the pattern which results on the oscilloscope screen when everything is working satisfactorily. When difficulty is encountered, a pattern as shown in Fig. 3 will be encountered. The vacuum or pressure changes cause the line to

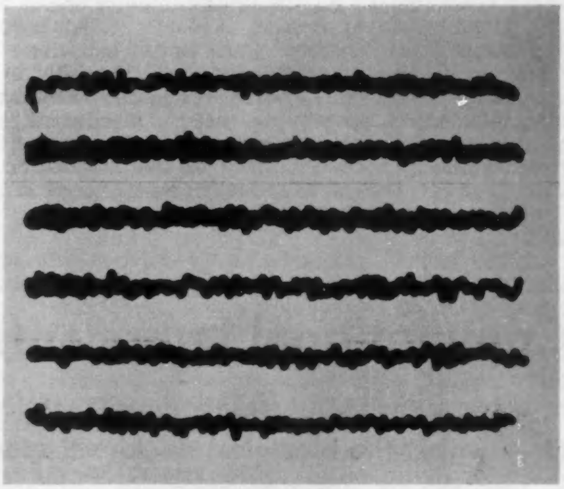


Fig. 5 — Normal engine noise as shown by noise and vibration pickup device.

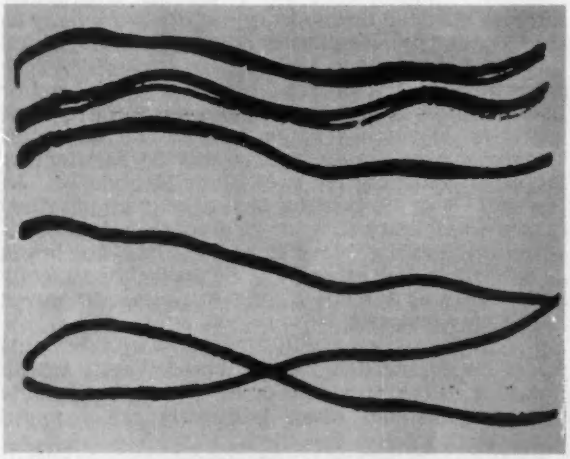


Fig. 3 — Valve trouble causes radical change in pattern of valve testing pickup.

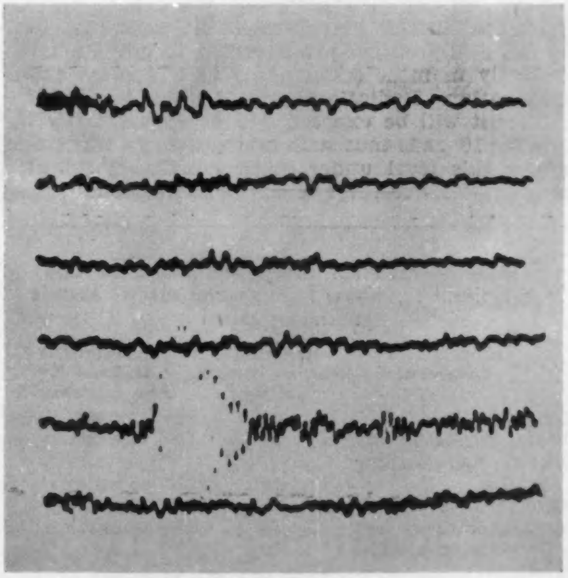


Fig. 6 — Severe detonation shows as high noise level on the fifth line.

take on a different aspect. The cylinder at fault may be determined by taking into account the relationship between valve timing and ignition timing.

Another of these transducer devices is one which tests timing advance and pickup. It uses the photoelectric principle, so that no connection to the engine is necessary. By means of light reflected from the flywheel timing mark, the photocell develops a pulse or pip which appears on the screen. By leaving the oscilloscope connected to the ignition system, each line starts when the spark plug fires. The timing impulse is then displayed on the screen at a distance related to the exact timing at that speed, as shown in Fig. 4. This photo is for a 6-cyl engine, so each line is 60 deg long. Here the spark plug fires 5 deg before top dead center and the timing mark is at top dead center. So, the timing impulse occurs 5 deg after the start of the line. A plastic scale is used to measure this in degrees. Basic timing can, therefore, be checked at idle. Advance can be checked by measuring the difference between readings taken at idle and at any predetermined speed. (Disadvantage of this system is that the timing mark must be cleaned or in some cases marked with paint or chalk. The head of the pickup device must be placed roughly ¼ in. from the access port without shadowing the mark from the source of light.)

A third transducer device is a noise and vibration pickup. This is a magnetic-type device which changes the field of an electromagnet as the noise or vibration is transmitted to it.

It is placed in contact with the engine either as a probe or by means of pliers adapted for the purpose. The pliers can be clamped to a head-bolt or similar protrusion. Ordinary engine vibrations are noted as shown in Fig. 5. The height of the signal given by this device will increase as a pickup comes closer to the source. Thus, the location of the source is obtained through probing, and the relationship to crank angle is obtained by its location on the pattern. If both of these coincide, the noise being picked up is related to spark or flame.

All of these devices represent the reduction of proved laboratory techniques to application in maintenance work—a type of progress peculiarly characteristic of current automotive engineering development.

To Order Paper No. 21B . . .
. . . on which this article is based, turn to page 5.

Conventional Lubricants . . .

. . . are sufficiently radiation-resistant for most nuclear power reactor applications. Only within the biological shield will special lubricants be needed.

E. D. Reeves

Esso Research & Engineering Co.

(Based on report to the SAE Nuclear Energy Advisory Committee)

CONVENTIONAL petroleum-base lubricants—both oils and greases—are expected to operate satisfactorily in most components of a nuclear power installation. Radiation levels to which much of the lubricant will be exposed will be substantially below the 10^8 rads that such lubricants can withstand. Above this level under static conditions—or at a somewhat lower level under dynamic conditions—radiation-caused viscosity changes and other degradation effects become too severe for satisfactory lubricant operation.

Table 1—Radiation Levels and Lubricant Life ("Typical" 12,500-kw boiling-water reactor electric generating plant)

Components	Operating Radiation Intensity, rads/hr	Lubricant Life to Attain 10^8 Rads Exposure, hr	
Turbine	0.2	10^9	(100,000 years)
Water circulating pumps	10^2	10^6	(100 years)
Remote fuel handling devices	10^5	10^3	(6 weeks)
Control drive mechanism	10^5	10^3	(6 weeks)
At reactor vessel wall	10^6	10^2	(4 days)
At reactor core center	10^{13}	10^{-5}	(1 sec)

Table 1 gives data developed by Hausman and Booser for levels existing in a "typical" 12,500-kw boiling-water reactor electric generating plant.

Thus it can be seen that current turbine oils, hydraulic oils, and oils and greases for overall plant lubrication can be expected to operate as satisfactorily in shielded areas of low radiation intensity as they do in the nonnuclear applications for which they were designed.

Gears, cams, motors, and pivots of control rod or fuel handling devices may be exposed to fairly high radiation intensities at or within the biological shield. Conventional greases will be satisfactory for use at intensity levels of 10^3 or 10^4 rads/hr. At levels of 10^5 or 10^6 rads/hr, it may be more practical to use solid lubricants, or hydrocarbon lubricants of improved radiation resistance. At least one brand of lubricants now offered on the market specifically for nuclear equipment is said to possess improved radiation resistance.

Within the core itself, hydrocarbon lubricants would be damaged beyond tolerance limits within hours or days. Graphite or molybdenum disulfide are recommended when lubricants are required under such intense radiation.

Lubrication problems of nuclear-powered seagoing vessels appear to be of the same order of mag-

nitude as discussed above for stationary powerplants. In marine applications, adequate reactor shielding is provided, and lubricant exposure to radiation is not excessive in most areas of use. Problems in nuclear aircraft systems may be more serious. Limitations on space and weight requirements necessitate compact installations and minimum shielding, exposing lubricants to more intense radiation. Although it is evident that lubricants of improved resistance will be required, access to information on the specific lubricant requirements of nuclear-powered aircraft is under Air Force restrictions. However, several major research organizations are working on this problem, and it is expected that lubricants of satisfactory radiation resistance will be available for this application when needed.

One DC-8 Jet Transport . . .

. . . is the equivalent of 3.5 DC-7's in producing passenger miles per hour of transportation—or 887 stage coaches.

Based on paper by

Ray D. Kelly United Air Lines, Inc.

(Presented at an SAE Southern California Section meeting and at a joint meeting of SAE Northern California Section and South Bay Division)

IT IS evident from Table 1 that the 550- to 600-mph jet transport is very efficient while in cruising flight. However, its overall performance is only as good as is permitted by factors such as traffic delays, taxi time, loading, servicing, and passenger and cargo handling. On the ground it loses its speed advantage. Airport facilities and methods must therefore provide the timesaving needed to match the increased productivity of the jet aircraft occasioned by its high flight velocity. The fastest airplane suffers most, in its ability to operate efficiently, whenever it is subjected to ground and traffic delays.

Time lost by the passenger on the ground is just as important to him as a similar number of minutes required because of slower flight equipment. Ten minutes saved for the passenger through better ground handling is the equivalent of 100 miles in cruising flight in a 600-mph transport.

There has been some questioning as to the probable need for so many big, fast aircraft. But it now appears certain that initial commitments were conservative rather than optimistic, and more jets and turboprops will be required to meet future air transportation needs.

After United's decision to purchase 30 DC-8's at approximately $155 million, there have developed additional monetary requirements as follows: $30 million for aircraft and powerplant spares, $10 to 12 million for new overhaul shop equipment, and $6.5 million for flight and ground training (including simulators and other aids). These expenditures are believed to be representative for other airlines as well.

The required shop facilities, tooling, and the like cannot be purchased "off the shelf." There is no "standard jet transport shop" in existence. The jet engine is an entirely new machine for the U. S. airlines. All of the planning and designing for the airline overhaul base must essentially proceed from scratch.

Needless to say this effort is vigorously under way now, with the time growing short in which to achieve full readiness for the first delivered airplanes, engines, and new accessory equipment.

Likewise the airline personnel training programs are currently getting into full swing. Key personnel and training teams are already attending classes sponsored by the manufacturers. Instruction and service manuals are being written. Training aids of all sorts are being developed.

Of primary interest in the latter category are the aircraft flight simulators. These will probably be purchased by the major operators. United will have its own DC-8 simulator in operation some time prior to the delivery of the first DC-8. Recently it has become known that jet engine simulators will also be available. These too will aid greatly in the training program. Good and bad operating practices can be demonstrated and critical engine conditions can be simulated without the hazard of engine damage, as would be likely with the use of an actual live engine for training work.

Another area of great concern to the airlines is the ground servicing equipment. Minimum ground and ramp time is achieved only with effective equipment, designed for the particular aircraft. A startling fact demonstrating the high cost of such specialized equipment is the approximately $50,000 price quoted for the passenger loading bridge planned for United Air Lines' DC-8's at Idlewild. Two will be required per airplane, so as to make simultaneous use of the front and rear passenger doors. By comparison, the 1929 Boeing 80-A tri-motored airplanes cost $85,000 each.

To Order Paper No. S46 . . .
. . . on which this article is based, turn to page 5.

Table 1—Passenger-Miles Transportation Productivity Comparison

Vehicle	Passengers—Speed, mph	Passenger-Miles per Hour	No. of Vehicles to Equal One DC-8
DC-8	123 × 575	71,000	1
DC-7	58 × 350	20,300	3.5
DC-3	21 × 180	3,790	18.7
Bus	40 × 55	2,200	32.2
Private Automobile	5 × 60	300	236.0
Stage Coach	8 × 10	80	887.0

Table 1—Passenger-Car Field Test—Northern Climate

(16,000 miles—premium-grade fuel, Chevrolet V-8's, 3000-mile oil change, no oil filter)

Oil	SAE Grade	Caterpillar Performance Level	Caterpillar Piston Demerit[a]		Field Test Deposit Demerits[a]		
			Ring Zone	Below Ring Zone	Piston Skirt Varnish	Ring Zone	Total Sludge
A	10W-30	Supplement I	0.4	0.15	3.8	1.6	1.6
B	30	MIL-L-2104A	0.2	0.09	4.2	1.6	2.2
C	10W-30	Below MIL	0.9	0.04	2.5	1.1	1.2

[a] 0 = clean; 10 = maximum deposits possible.

Table 2—Taxicab Fleet Test—Metropolitan New York

(45,000 miles—regular-grade fuel, 6-cyl Chevrolets, 7000-mile oil change, no oil filter)

Oil	SAE Grade	Caterpillar Performance Level	Caterpillar Piston Demerit[a]		Fleet Test Deposit Demerits[a]				
							Sludge		
			Ring Zone	Below Ring Zone	Piston Skirt Varnish	Ring Zone	Total	Oil Screen	Oil Rings
D	30	MIL-L-2104A	0.2	0.03	2.1	6.6	2.4	3.5	6.9
E	30	MIL-L-2104A	0.3	0.02	2.2	7.0	6.3	9.8	6.9
F	10W-30	Below MIL	0.9	0.03	2.2	8.0	5.8	9.0	8.6

[a] 0 = clean; 10 = maximum deposits possible.

Don't Ask Gasoline-Engine Oils To Pass Diesel-Engine Tests

Based on paper by

J. K. Patterson and W. E. Waddey

Esso Research & Engineering Co.

THERE has been a tendency, in recent years, to apply diesel-engine test standards to gasoline-engine lubricants. Extensive field tests, representing over 2,000,000 miles of service, and including a wide range of automotive equipment requirements, show that such a practice is not justified. These field tests show that Caterpillar diesel-engine lab tests of oils do not predict their field performance for the wide variety of gasoline-engine applications studied.

Detailed results from these field tests are presented below.

A 16,000-mile caravan-style passenger-car field test was conducted on three crankcase lubricants. The driving schedule consisted of about 25% city operation (30 mph maximum) and 75% country operation (50 mph maximum). Five Chevrolets (V-8) operated on each oil. These oils differed considerably in Caterpillar-engine test performance. Oil A was Supplement I quality; oil B was MIL-L-2104A approved; oil C, containing an additive specifically designed for gasoline-engine service, was well below the requirements for MIL-L-2104A approval, giving unsatisfactorily high deposits in the L-1 Caterpillar test (0.4% S fuel) after only 240 hr. After 16,000 miles of mixed city-country driving, oil C gave significantly less deposits than oil A or oil B. Average deposit demerit ratings are shown in Table 1.

It is apparent that the Caterpillar-engine test performance failed to predict the passenger-car field performance of these oils.

Severe Stop-and-Go Services

Taxicabs—A 45,000-mile taxicab fleet test was conducted on three lubricants. Each oil was eval-

Table 3—Delivery Truck Fleet Test—Light Duty—I

(8000-miles, high-deposit regular-grade fuel, 6-cyl Chevrolets, 4000-mile oil change, no oil filters)

Oil	SAE Grade	Caterpillar Performance Level	Caterpillar Piston Demerit[a] Ring Zone	Caterpillar Piston Demerit[a] Below Ring Zone	Fleet Test Deposit Demerits[a] Piston Skirt Varnish	Ring Zone	Sludge Total	Sludge Oil Screen	Sludge Oil Rings
H	30	Series 2[b]	0.7	—	7.6	3.7	2.3	7.0	6.3
J	30	2-104B	0.2	—	8.5	2.5	1.8	3.5	1.9

[a] 0 = clean; 10 = maximum deposits possible.
[b] Supercharged laboratory Caterpillar engine test; 1% minimum fuel sulfur content.

Table 4—Delivery Truck Fleet Test—Light Duty—II

(8000 miles—high-deposit regular-grade fuel, 6-cyl Chevrolets, 4000-mile oil change, no oil filters)

Oil	SAE Grade	Caterpillar Performance Level	Caterpillar Piston Demerit[a] Ring Zone	Caterpillar Piston Demerit[a] Below Ring Zone	Fleet Test Deposit Demerits[a] Piston Skirt Varnish	Ring Zone	Sludge Total	Sludge Oil Screen	Sludge Oil Rings
K	30	Nonadditive	—	—	9.5	3.3	3.4	10	5.7
L	30	MIL-L-2104A	0.3	—	10	2.2	3.0	10	2.0
M	30	Below MIL	1.2	1.0	8.1	1.6	1.6	5.1	1.0

[a] 0 = clean; 10 = maximum deposits possible.

Table 5—Over-the-Road Gasoline-Engine Truck Fleet Test

(30,000 miles—regular-grade fuel, Internationad RD 450 engines, 10,000-mile oil and oil filter changes)

Oil	SAE Grade	Caterpillar Performance Level	Caterpillar Piston Demerit[a] Ring Zone	Caterpillar Piston Demerit[a] Below Ring Zone	Fleet Test Deposit Demerits[a] Piston Skirt Varnish	Ring Zone	Sludge Total	Sludge Oil Ring
N	30	MIL-L-2104A	0.1	0.02	0.9	3.9	1.1	2.1
D	30	MIL-L-2104A	0.2	0.03	1.9	2.6	0.1	0

[a] 0 = clean; 10 = maximum deposits possible.

uated in four 6-cyl Chevrolets under typical New York City taxi service conditions. These conditions and the extended oil drain periods (7000 miles-typical of this fleet) provided severe sludging service. Oils D and E contained the same detergent additive, but were formulated with base stocks from different crude sources. Although oils D and E gave equivalent Caterpillar-engine test performance at the MIL-L-2104A level, oil D gave significantly less engine sludge after 45,000 miles of taxi service, demonstrating the importance of base stock in this field service. Oil F, though well below the MIL-L-2104A level in Caterpillar-engine test performance, gave taxi fleet performance approximately equivalent to MIL-L-2104A level oil E. Average deposit demerit ratings are shown in Table 2.

Delivery Truck—An 8000-mile delivery truck fleet test was conducted on two lubricants using a high-deposit fuel to accelerate engine deposit formation. Each oil was studied in four 6-cyl Chevrolets under typical door-to-door delivery truck service conditions. These oils differed considerably in Caterpillar-engine test performance. Oil H gave excellent Series 2 Caterpillar test performance; oil J was 2-104B level. After 8000 miles of door-to-door delivery truck operation, the Series 2 oil H gave higher deposits than 2-104B oil J in every regard except piston skirt varnish. Average deposit demerit ratings are shown in Table 3.

Another 8000-mile delivery truck fleet test was conducted on three lubricants, again using a high-deposit fuel. Again, each oil was studied in four Chevrolets in typical door-to-door delivery truck

service. These oils also differed considerably in Caterpillar-engine test performance. Oil K contained no detergent additive; oil L gave MIL-L-2104A performance; oil M was well below MIL-L-2104A level in Caterpillar performance. However, after 8000 miles, oil M gave less deposits than MIL-L-2104A level oil L, which in turn was little better than oil K. Average deposit demerit ratings are shown in Table 4.

Thus, in a variety of severe stop-and-go services, the Caterpillar-engine test performance has failed to predict the field performance (particularly sludge handling ability) of the oils.

Over-the-Road Gasoline-Engine Truck Service

A 30,000-mile gasoline-engine truck fleet test was conducted on two lubricants. Each oil was used in four trucks with 450 cu in. International engines. These oils were both MIL-L-2104A oils, giving nearly identical Caterpillar engine test performance. After 30,000 miles of heavy-duty freight hauling service, oil D, containing a detergent additive developed specifically for gasoline-engine lubricants, while giving slightly higher piston skirt varnish, gave significantly less ring and sludge deposits. Average deposit demerit ratings are shown in Table 5.

Thus, in this over-the-road service, the Caterpillar diesel-engine test did not distinguish between oils giving widely different field performance in gasoline-engine trucks.

To Order Paper No. 1C . . .
. . . on which this article is based, turn to page 5.

Gasoline-Engine Oil Evaluation . . . Today and Tomorrow

Most motor oil suppliers, aware of the limitations of the diesel-engine test as a measure of gasoline-engine performance, formulate gasoline-engine lubricants using a variety of engine tests. They measure not only deposit formation, but also wear octane requirement increase, antirust characteristics, and other characteristics. The performance of the oil is then confirmed in field tests. All of these evaluations are normally carried out in equipment and under service conditions for which the lubricant is intended.

Insistence that these oils also pass arbitrary diesel tests results in a double standard, which at best can only serve to increase the difficulty and cost of developing superior gasoline-engine lubricants and which at worst can lead to the achievement of diesel-engine performance at the expense of performance in the equipment for which the oil is intended. Oils containing additives designed for use in both gasoline- and diesel-engine service must be evaluated in each of the applications for which they are intended.

As the accompanying article shows, there is real need for a laboratory-engine method for predicting gasoline-engine field performance. CRC efforts to develop a suitable research technique for this purpose are commendable. The problem of deposit formation in gasoline engines, particularly under stop-and-go and extended idle service conditions, has been studied extensively for many years. Many of the laboratory tests have had definite limitations, primarily as a result of their lack of sensitivity.

A laboratory gasoline-engine test (ER 4-45) developed in the authors' laboratory has been found to be very useful for screening lubricants for their deposit-forming tendencies in field service. Further work has led to the development of a cyclic test for predicting the field performance of lubricants, not only as regards deposits and sludge, but also with respect to ring and cylinder wear, valve train wear, hydraulic valve lifter lubrication, octane requirement increase, and other fuel-lubricant factors in engine operation. The details of this work and a description of the test method will be published in a separate paper.

Short Take-offs for Supersonic Aircraft

A 25% drop in take-off distance is possible with blown boundary layer control by using engine-supplied compressor bleed air.

Based on paper by

H. C. Higgins

Boeing Airplane Co.

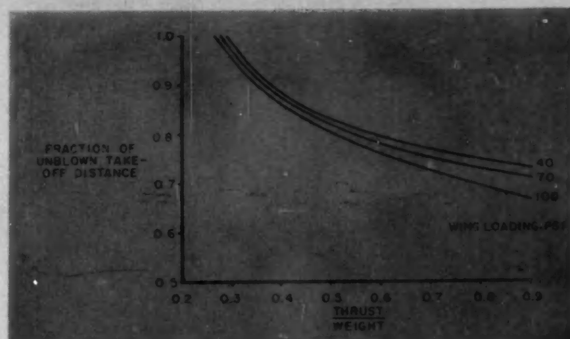


Fig. 1—Take-off distance drops with optimum boundary layer control as the power of the airplane goes up. The thrust-weight ratios shown indicate beneficial effects for supersonic airplanes

BLOWN BOUNDARY LAYER CONTROL can reduce take-off distances up to 25% for high performance airplanes, studies at Boeing show. And, this improvement is not nullified by a drop in cruise performance because wing loading can be increased 50% or better for low drag at high speeds.

Efficient control is possible in the thrust-to-weight ratio range of 0.5–1.0. Below 0.5 too much power is drained from the engine and take-off distances go up. Above 1.0 you've got a rocket. Fig. 1 demonstrates the drop in take-off distance over a 50-ft obstacle as the thrust-weight ratio increases.

Nonsupersonic craft will not benefit from this system because of low thrust-weight ratios. Bleeding air from their compressors cuts take-off ability. However, modern jet engines can stand up to 10% bleed air. The optimum amount of bleeding for boundary layer control parallels this trend, as shown in Fig. 2.

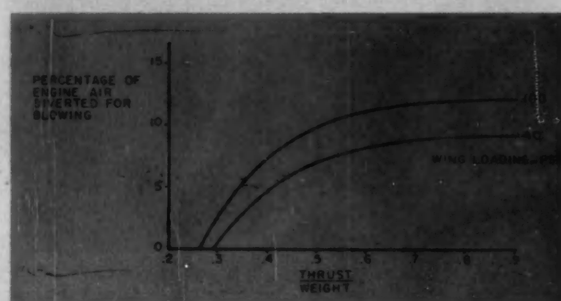


Fig. 2—Optimum boundary layer air requirements come close to matching the 10% bleed air possible from some modern jet engines.

Better high speed performance must make up the extra weight and complication of the boundary layer system. A 50% decrease in wing area is indicated in Fig. 3, where wing loading is used to measure performance.

In the Boeing study only the "potential flow" region of boundary layer control was investigated. At higher boundary-air-flow rates further increases in wing lift are possible, but not as profitable. Also the work was limited to engine supplied compressor bleed air. Other blowing systems would include exhaust gas and auxiliary gas generators. Suction-type boundary layer control was not considered.

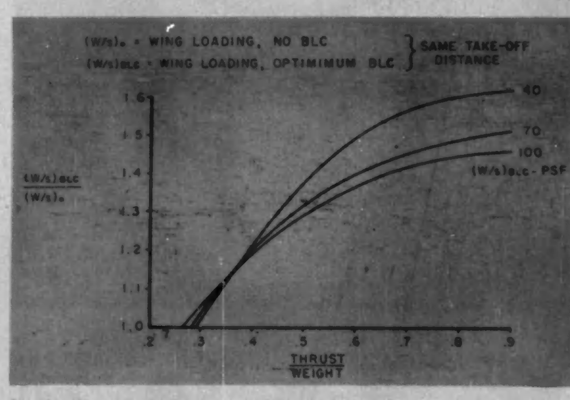


Fig. 3—The boundary layer control system (BLC) pays off in smaller wings for high speed flight

To Order Paper No. 37B . . .
. . . on which this article is based, turn to page 5.

Some Examples of Poor Cab Design

TROLLEY BRAKE fixtures are interposed between operator's eyes and the instrument panel. The calf of the leg hits the front of the seat.

CONFUSION guaranteed. The instrument dials have their figures arranged in opposite directions, one clockwise, the other counterclockwise. Moreover, the two switches must be manipulated in opposite directions for the OFF position and in opposite directions for the ON position.

Truck

Need Further

Based on paper by

Ross A. McFarland and Richard G. Domey
Harvard School of Public Health

A STUDY of 10 different trucks creates the doubt that manufacturers have reliable standards to insure accommodating variations of human body size, or use such standards to maximum advantage if available. Efficient and safe operation demands that much more attention be paid to:

- **Overall cab size.**
- **Seating.**
- **Arrangement of instruments and accessories.**
- **Environmental conditions.**

Overall Cab Size

With few exceptions the driver's cab was found to be too small for operators larger than the 65th percentile. For example, if seats were adequately adjustable it would be impossible to place them most advantageously in most cabs because of space limitations or peculiarities of cab shape.

Seating

In some instances the physical dimensions of seats did not meet certain minimum human-sizing seating criteria, especially with respect to width and depth of the seat pan, and width and height of seat back.

There was no single instance where the adjustability available in either the vertical or horizontal plane met minimum criteria. On one vehicle a certain seat could not be adjusted in any direction. At least half the seats could not be adjusted vertically. In almost all cases where seats could be adjusted in either plane, the range was too small.

In almost all trucks the placement, static dimensions, and degree and range of seat adjustability clearly favored the smaller driver. Some of the forward adjustibility provided was wasted because if the seat was moved forward the space between the steering wheel and seat back became less than the abdomen depth of persons at the 5th percentile. It would have been better had the seat rack been mounted nearer the rear of the cab, but this usually was impossible in view of cab structure.

Arrangement of Instruments and Accessories

There is evidence that dials and gages have been

Cabs Improvement

placed nearer the operator than when a prior study was made in 1954. Nevertheless, the variation found in the location, placement, size, degrees of visibility, presentation of information, and angle of instruments suggests that displays are not designed to follow any special pattern, or to depend upon any system related to common human factors. Some gages and dials were wholly or partly hidden behind other instruments mounted on the steering column. Often a certain gage measuring the same thing would be found to vary widely in design in different vehicles. Tachometers afford a specific example.

At least 22% of all hand controls in the 10 vehicles were considered to be located too far from the operator. Others were placed in disadvantageous positions, such as one important lever which was almost invisible behind the steering column and difficult to reach. In certain vehicles some operators could not reach the pedals without striking their thighs on the steering column or shift levers. Some controls impeded the operation of others and some required excessive effort to operate. Although a great deal of auxiliary equipment was included in some cabs, the additional space required had not been built into the cabs, so placing was disadvantageous.

The curvature of windshields varied, giving varying degrees of distortion. In some instances the windshield wipers did not fit the curvature of the windows they were supposed to clean. Mirror size and quality were highly variable and often the mountings did not prevent vibration. Visors commonly did not wholly shield the eyes and there was considerable uncomfortable leakage. Some vehicles had only a single visor.

Environmental Conditions

The noise level approached the discomfort level in some vehicles. Reasonable amounts of CO were found in some cabs, but no cab had a dangerous concentration. Only preliminary measurements of temperature and humidity were attempted because of the wide variation of environmental conditions under which the vehicles were studied. In general, humidity levels were not excessive. Temperature was found to be highly variable. This area of biotechnology needs intensive development..

To Order Paper No. 19B . . .
. . . on which this article is based, turn to page 5.

More examples of poor cab design

THE SHIFT LEVER impedes the leg action of the driver. The accelerator pedal and the air brake pedal may be depressed simultaneously.

THE COAT HANGER situated close to the temple and eye of the driver constitutes a totally unnecessary hazard.

WHEN THE DRIVER attempts to lower or raise the window he strikes his fist on the protruding light switch.

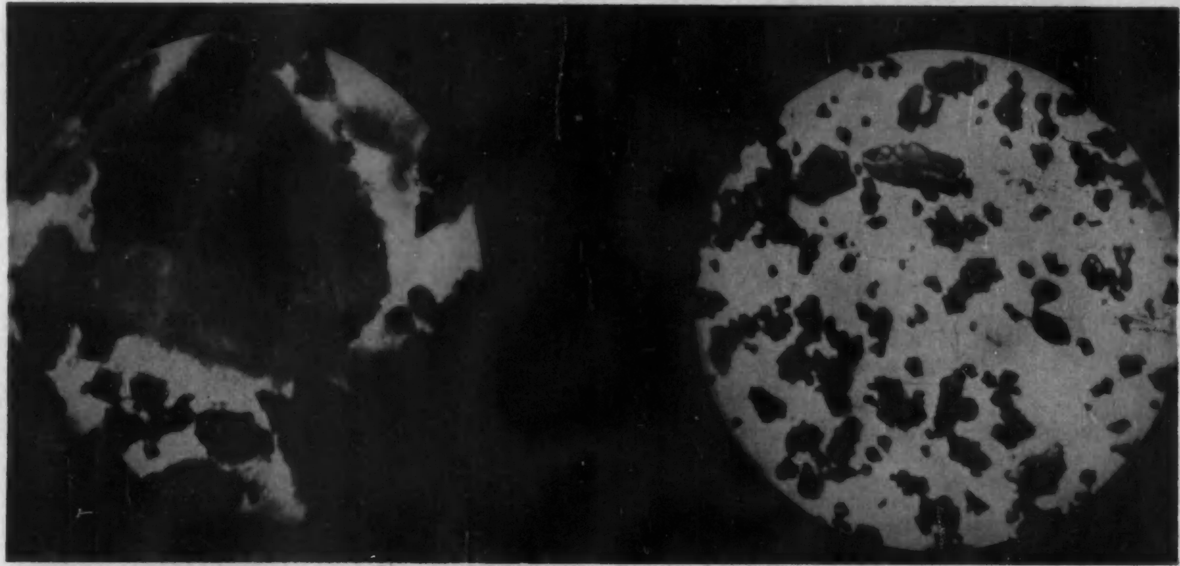


Fig. 1 — Left: metallurgical micrograph (original taken at 750X) of 250 mesh powdered coal, showing particles in excess of 100 microns. Right: electron micrograph (original taken at 6750X) of irradiated coal, showing that particle size has been reduced to ½-1 microns.

Nuclear Energy Helps Bring

Based on paper by

Ray McBrian

Director of Research, Denver Rio Grande Railroad Co.

IN THE not too distant future, irradiation may be used to reduce the size of particles in fuel, thereby improving its burning qualities. Limited tests in our laboratory show that certain fuels are definitely improved in this respect — and that these effects can be maintained for as long as 60–90 days. (Many problems, will, of course, have to be solved before large volumes of fuel can be irradiated economically.)

Our irradiation studies of fuel are proceeding along two main lines:

- Irradiation of powdered coal so as to produce particles small enough to be dispersed in diesel fuel.
- Irradiation of liquid fuel to reduce particle size and thereby assure better combustion.

Irradiation possibly can be used to reduce the size of ordinary ground coal sufficiently so that it can be dispersed in diesel fuel.

In our studies total radiation varied from 1.8×10^6 to 24×10^6 roentgens. Exposure time varied from a few hours to 24 hr. Radiation intensity varied from 250,000 to 1,000,000 roentgens per hr. The coal was radiated at Brookhaven National Laboratories.

The left view of Fig. 1 shows a metallurgical micrograph (original taken at 750×) of 250 mesh ground coal. Particle size is in excess of 100 microns. At the right is an electron micrograph (original taken at 6750×) of the coal after radiation. Particle size has been reduced to ½–1 microns.

The beginnings of a soluble dispersion of the coal in the fuel is shown in the electron micrograph of a coal-fuel-oil mix (Fig. 2).

We have already run a small diesel engine (5-hp Witte) using irradiated coal in No. 1 distillate. The engine ran for ½ hr, with satisfactory combustion. The output was comparable to that obtained with

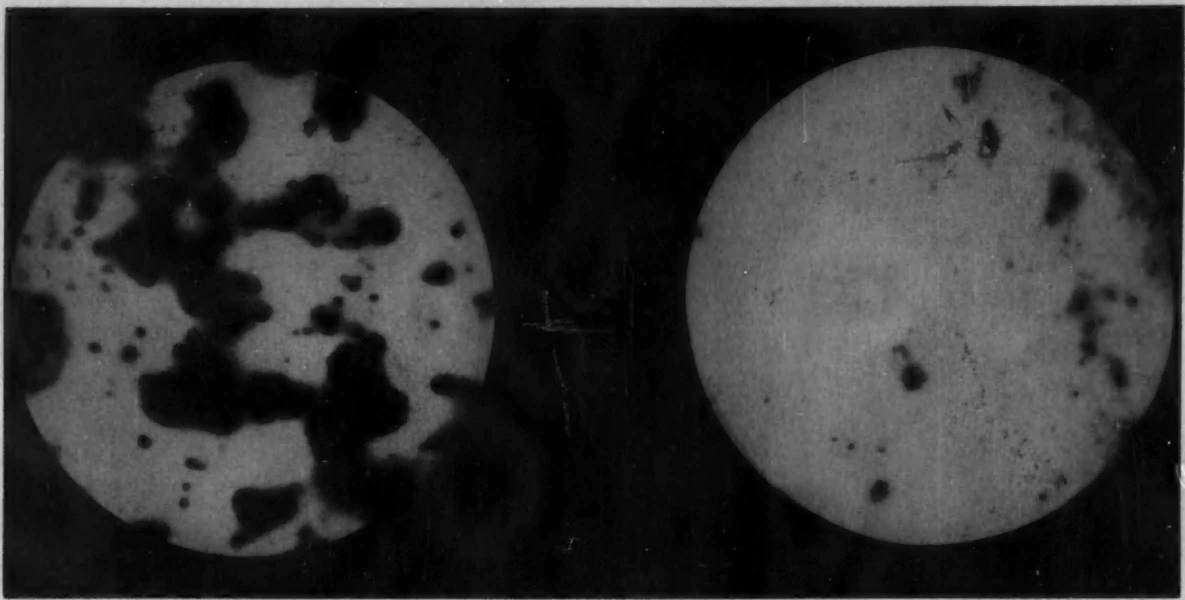


Fig. 2 — Electron micrographs of coal and fuel oil mixture, showing that, thanks to the use of catalysts and irradiation, the coal is beginning to disperse solubly in the fuel oil. Left: particle matter is not crystalline, but has the appearance of particles found in liquid petroleum. Right: similar appearance, with smaller particle size, indicating more solubility.

Better Fuels

regular diesel fuel. One problem was that the cooling water temperatures tended to rise slightly during the use of the coal and oil mixture.

All this work is, as yet, highly experimental. We are varying dosages, geometry, type of radiation, and oil and coal combinations, in an effort to determine the best possibilities.

Irradiated Liquid Fuel

Actual field and road service shows that to use diesel fuels with a minimum of engine trouble, particle size must be held to 1/10–¼ micron. (A typical diesel fuel may have particles in excess of 10–30 microns.)

The need for particle size reduction is particularly acute for high-sulfur fuel. Use of the tracer technique (with the radioactive isotope sulfur 35 as tracer) shows that when the high-sulfur fuel has:

- Particles of normal size (over ¼ micron) an appreciable amount of sulfur finds its way past the rings and into the lubricating oil. This results in high ring wear rates.
- Finely dispersed particles, then the sulfur is burned to SO_2, which goes out the exhaust as a gas. Ring wear is thus greatly reduced because the sulfur does not form either SO_3 or large particles of an abrasive nature.

We have experienced a certain amount of success and also some failures in our efforts to reduce fuel particle size by irradiation.

Here's the story of a fuel that was not improved by irradiation, despite our best efforts. As received from the gamma facility (where it received a dose of 1×10^7 roentgens) it had a satisfactory particle size. But, after one-week's exposure to light, agglomerates began to form. After exposure to 1×10^8 roentgens and one week of aging, crystal deposits and sludge began to form. When the radiation was increased to 3×10^8, the fuel showed sludging as received, and deteriorated even more during the one-week aging period.

In other cases irradiation did give a definite improvement in particle size. For instance, Fig. 3 shows how neutron irradiation reduced particle size in a leaded gasoline. The center electron micrograph shows how the unradiated gasoline looked after exposure to sunlight for three days. At the left is the same fuel exposed to gamma radiation (1×10^7) and exposed to light for three days. At the right is the gasoline after exposure to neutron irradiation (2×10^8) and then to the light for the same length of time.

Future Studies

These and other preliminary studies have con-

Fig.3 — Electron micrographs of leaded gasoline after exposure to sunlight for 3 days. Center: unradiated gasoline. Left: irradiated gasoline (gamma radiation of 1×10^7 roentgens). Right: irradiated gasoline (neutron radiation of 2×10^8 roentgens).

vinced us of the possibilities of using radiation and radioactive isotopes to improve the operation of internal-combustion engines. We need further information, however, about what can be accomplished with different types of irradiation, such as:

- Spent fuel elements.
- Gamma sources, including accelerators — linear and horizontal, cobalt 60 sources, actual pile irradiation studies, X-rays.
- Neutron sources.

We also need to study the effect of methods of radiation, including geometric configurations for sample holding, use of catalysts or other addition agents, including dispersants.

Excerpts from discussion . . .

By J. H. Macpherson, Jr.

California Research Corp.

WHEN a petroleum fuel is irradiated, hydrocarbons of both higher and lower molecular weight than present in the original fuel are formed. Also, some hydrogen is freed from the molecules and evolves as a gas. Reactive centers, resulting from radiolytic ionization, polymerize to form heavier hydrocarbons. Therefore, the predominant products are higher molecular weight hydrocarbons.

Resulting changes in physical properties are what would be expected from such an increase in average molecular weight. For example, the following changes would result from 5×10^9 roentgens irradiation of JP-5 jet fuel. The viscosity at 100 F would increase from 2 cs to about 500 cs, which is about that of an SAE 60 lube oil. The ASTM 50% boiling point would increase from 425 F to 625 F. Density would increase from 0.84 to 0.94.

We used two procedures for measuring the gum formed by irradiation. One was the measurement of filterable suspended gum of 0.1 micron particle size and larger. The other one measured the gum adhering to the fuel container used for the irradiation. This involved removing the gum with solvents, evaporating the solvents, and weighing the residue. We found that the amount of suspended gum in the fuels was very small and usually exhibited a slight upward trend with increased irradiation dosage. For example, unirradiated fuels have 0.2–0.8 mg/100 ml suspended gum, while fuels irradiated up to 1×10^9 roentgens had 0.2–1.8 mg/100 ml. Adherent gum removed from fuel containers also increased with dosages in most cases; however, the maximum quantities measured were only 0.09 mg/100 ml at 1×10^8 roentgens and 0.5 mg/100 ml at 1×10^9 roentgens.

Thermal stability of jet fuels was found to vary with irradiation dosage and fuel characteristics. In general, exposure to higher dosages ($5 \times 10^8 - 10^9$ roentgens) improved thermal stability. Exposure to $10^4 - 5 \times 10^8$ roentgens frequently reduced thermal stability. Thermal stability was measured with the CFR fuel coker, which is designed to evaluate high-temperature filterability and deposition tendencies of jet fuels under dynamic conditions. The test procedure requires prefiltration of the test fuel, which minimizes the effect of existing suspended gum. Probably this is why we found no relationship between thermal stability and suspended gum.

To Order Paper No. 16A . . .
. . . on which this article is based, turn to page 5.

Niobium . . .

. . . a prospect for aviation gas turbines

Based on paper by

W. S. Hazelton

Aviation Gas Turbine Division, Westinghouse Electric Corp.

NIOBIUM melts at a temperature high enough to make it attractive for very high-temperature use. It is relatively light, ductile, and sufficiently abundant for specialized uses. Its relative freedom from serious brittleness problems and apparent tolerance for alloying and impurity elements indicate that oxidation resistant alloys with good mechanical properties can be developed.

The low modulus of niobium is its chief disadvantage, but many uses can be found for it where this can be overcome by design.

It should not be expected that niobium will take the place of molybdenum entirely, because the very high modulus of molybdenum will always make it more attractive for some parts. Indications are that both materials will be used in future aviation gas turbines, increasing their performance and scope of operation.

There are several general categories considered when any new material is evaluated for high-temperature service. These can be listed as follows:

1. Strength and ductility.
2. Oxidation resistance.
3. Ease of fabrication.
4. Cost and supply.

A comparison of niobium with molybdenum in each of these categories should give a good picture of its potential value in aviation gas turbine technology.

Strength and Ductility

Very little is known about the strengths ultimately attainable in either molybdenum- or niobium-base alloys, but available data can be used to good advantage. Fig. 1 shows some typical 100-hr rupture strengths of alloys. The better molybdenum alloys show a distinct superiority in rupture properties, possibly because they have been under development longer. However, niobium alloys show a marked advantage over Inco 713C. And with present emphasis on their development, properties approaching those shown for the best molybdenum base alloys can be expected in the near future.

The modulus of elasticity must be considered in many applications, and in parts subjected to buckling loads it is often of prime importance. In this respect, molybdenum is far superior to niobium, as shown in Fig. 2. (Data for niobium may be somewhat in error since there are contradictory values given in the literature.) This low modulus is a serious disadvantage of niobium, but alloys of aluminum and magnesium have been used for important structural parts even though they have very low moduli. Furthermore, there are some compensating advantages.

Thermal conductivity and expansion also must be

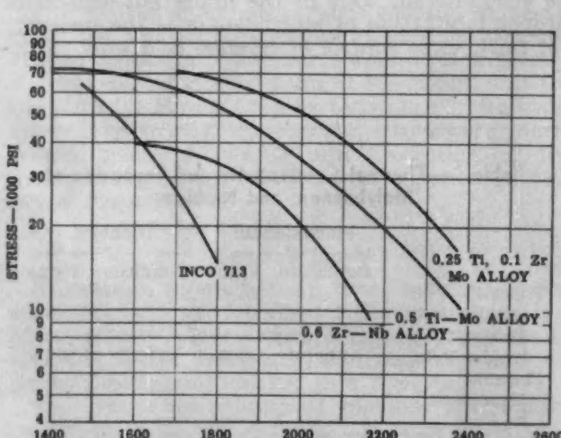


Fig. 1—100-hr rupture strength of several alloys

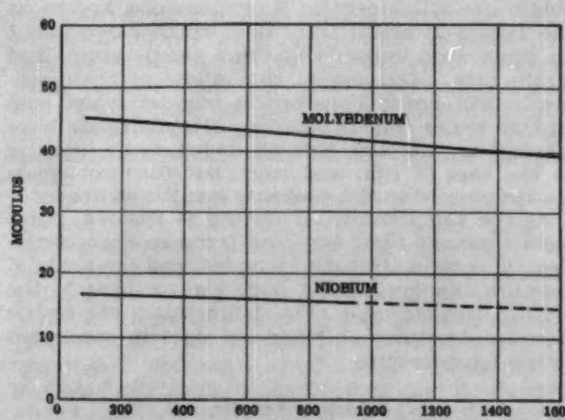


Fig. 2—Modulus of elasticity of niobium and molybdenum

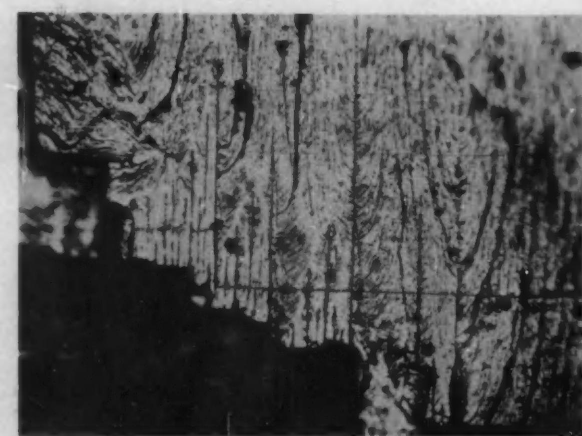


Fig. 3 — Fractograph of niobium, showing intersecting 001 cleavage planes (originated magnification 150×). (Photo by L. L. France, Westinghouse Research Laboratories)

considered in design and are often very important in determining the durability of a high-temperature part. Table 1 shows how niobium and molybdenum compare in these properties. Niobium has a higher thermal expansion and a lower conductivity, but with respect to these properties one element cannot be said to be better than the other—they are merely different. Some applications call for a high heat conductivity; some require limited heat transport.

High-temperature parts very often fail by thermal fatigue caused by cyclic stresses induced in the parts when they are heated and cooled. The magnitude of these thermal stresses is directly related to the thermal expansion, conductivity, and elastic modulus of the material. Both molybdenum and niobium can be expected to have excellent thermal fatigue resistance because of their low coefficient of thermal expansion. Although molybdenum has a higher conductivity, niobium's lower modulus will tend to offset this and the materials should both be resistant to thermal fatigue.

Iron, chromium, tungsten, molybdenum, and niobium are all subject to a phenomenon known as the ductile-to-brittle transition, which is dependent on grain size, impurity content, temperature, and strain rate. This means that alloys of these elements will break in a brittle manner when cold and/or under impact loading. Metallurgists have learned to minimize this phenomenon by alloying in the case of iron and steel, but the problem is always present in the elements mentioned above.

As the temperature of testing is lowered, these metals change their flow and fracture characteristics. The yield strength increases, and the mode of fracture changes from a ductile shear type to the brittle cleavage type. Fig. 3 illustrates the brittle cleavage fractures obtained on niobium specimens at low temperature.

Oxidation Resistance

With the exception of special gas turbine apparatus, such as turborockets, the high-temperature parts of aviation gas turbines are subject to a highly oxidizing atmosphere. Again nature seems to be against the metallurgist, because all of these high melting elements that have been considered have practically no oxidation resistance at the temperatures of the desired applications. Molybdenum is particularly poor, because its oxide, MoO_3, becomes volatile below 1000 F, and above 1450 F comes off in clouds of white smoke. From a practical standpoint, niobium is not much better, although its oxide is not volatile.

There are two approaches that can be used to overcome this difficulty. For example, the poor oxidation resistance of iron can be helped greatly by alloying it with chromium and other metals. This approach has been tried on molybdenum with no practical success. Sufficient protection of molybdenum parts has been achieved by various coatings and claddings to make the element useful for many applications, but these give only temporary and somewhat unsatisfactory results. Turbine nozzle vanes fabricated of Inconel-clad molybdenum sheet represent one of the more successful applications. These have been engine tested more than 30 hr at temperatures over 2000 F with very satisfactory results. Niobium can be protected in a similar manner.

The problem of protecting niobium is much less severe, partly because its oxide is not volatile, and minute imperfections in the coating are not as deleterious. The most significant difference between molybdenum and niobium is the possibility of developing an oxidation resistant alloy of the latter with adequate mechanical properties. Several investigators have developed niobium-base alloys with excellent oxidation resistance up to 2250 F, and even better alloys can be expected.

Ease of Fabrication

Obviously, if a material is to be useful for structural components it must be fabricated easily, using practical techniques. Molybdenum can be forged into useful shapes, using proper control of the temperature and amounts of reduction. It can also be rolled into bars and sheets. There is no apparent evidence of increased difficulty with niobium. In fact, experience indicates that fewer troubles will be encountered. One of the important aspects of proper fabrication of molybdenum is the necessity for fairly close control of residual cold work in the

Table 1—Thermal Conductivity and Expansion of Molybdenum and Niobium

	Molybdenum		Niobium	
	Condition	Value	Condition	Value
Thermal Conductivity, Btu/sq ft/hr/deg F/in.	212 F	800	212 F	377.5
Thermal Expansion, in./in./deg F×10^{-6}	RT-1800 F	3.4	RT-1800 F	3.8

metal. With molybdenum of commercial quality, and with available alloys, a residual amount of cold work representing about 50–70% reduction is necessary to give the required strength and ductility. Too little cold work will make the molybdenum both weak and brittle, while too much will lower the recrystallization temperature, reducing its strength at temperatures over 2000 F.

To obtain this optimum amount of cold work, molybdenum alloys must be recrystallized at the proper point in the rolling or forging cycle and final reduction to size accomplished at temperatures ranging from room temperature to 2400 F, depending on the particular alloy and final product. Die design and forging sequences must be especially controlled in the manufacture of intricate forgings to assure correct amounts of reduction throughout the finished part.

Probably the first niobium-base alloys to be commercially available for structural parts will also be strain hardened, and will require controlled amounts of cold work to give them desirable properties. Limited experience with niobium alloys indicates that close control may be required until alloys are developed which do not depend on work hardening for their properties. Little is known about forging techniques, but the higher general ductility of niobium permits most rolling operations to be accomplished at or near room temperature.

Forming sheet metal is one of the most important fabrication jobs that must be considered for aviation gas turbine parts. Both molybdenum and niobium are readily formed by the normal techniques, but molybdenum often must be heated to 600–1000 F for severe forming. Indications are that this may not be necessary with niobium. This is not a serious disadvantage, because such warm working is normal practice in many magnesium and titanium fabrications.

Joining is a more serious problem. Welding by such processes as inert gas shielded arc will cause the weld metal to pick up gaseous impurities, such as nitrogen and oxygen. These can seriously embrittle both molybdenum and niobium. Many problems remain unsolved in the field of welding both molybdenum and niobium, but the embrittlement problem seems to be of a much lesser magnitude in niobium.

The molybdenum alloy vanes mentioned previously are excellent examples of accomplishments with molybdenum. The parts were stretch formed of Inconel-clad molybdenum at 600–800 F, and the trailing edge tack welded by resistance. The trailing edge joint and the exposed edges were nicrobrazed to effect joining and protection of the sheared edges. No difficulties were experienced with any of the processes.

Cost and Supply

At present, niobium is 10 times more expensive than molybdenum for similar purity and product form. But with increased production, prices can be expected to fall drastically, and may well be competetive with molybdenum in a few years.

The future availability of niobium and molybdenum is unknown, although it is believed both will be in very adequate supply for specialized uses in aviation gas turbines. Extensive deposits of niobium ore have been found, a considerable amount of it on this continent. Known reserves in 1955 were 10 times as great as during World War II. Molybdenum, too, is high on the strategic list, although the situation was never considered to be as serious as with niobium.

To Order Paper No. 14A . . .
. . . on which this article is based, turn to page 5.

Based on discussion

By Robert I. Jaffee

Battelle Memorial Institute

THE high-temperature properties shown for the Nb-0.6Zr alloy are considerably better than those of pure niobium, in fact, about three times as good. The zirconium in this alloy actually is an impurity, since it is understood that the material is commercial unalloyed niobium. Whether zirconium is an impurity or not is immaterial if it is doing an effective job in improving the high-temperature strength of niobium. The molybdenum alloys which show so much promise also contain zirconium or titanium in about the same amounts. However, it has been found by others that titanium and zirconium are rather ineffective in improving the high-temperature strength of niobium. Therefore, one wonders if the high properties shown were the result of internal oxidation during vacuum rupture testing. Also, the ductility of the alloy during test and the possible embrittlement at room temperature are questions that need answering before the high properties shown can be taken as typical of niobium alloys.

The good low-temperature ductility of niobium in the recrystallized condition is a big advantage of niobium over molybdenum, which is brittle at room temperature. Another advantage is that welded niobium is ductile, whereas welded molybdenum is very brittle at room and moderately elevated temperature. A third advantage of niobium is its ability to be cold rolled to a high-quality foil and sheet, which, combined with its weldability, makes niobium suitable for high-temperature honeycomb and sandwich construction.

The oxidation characteristics of niobium are much superior to those of molybdenum, and there are good prospects that oxidation-resistant alloys will be developed which will permit elevated-temperature service for short periods at least. However, if the niobium alloys have to be protected by a coating for long-time service, niobium alloys may prove inferior to molybdenum alloys because of greater interdiffusion between the coating and the core material.

The development of niobium for aircraft and missile applications has only really begun. It is my opinion that neither molybdenum or niobium will have a clear field of advantage. Molybdenum alloys probably always will develop superior elevated-temperature strength. The coating problem for molybdenum will not be solved for many types of application. Niobium's chief areas of application probably will be where its low-temperature ductility and weldability are needed. Thus, these metals will complement rather than compete with each other in the high-temperature aircraft field.

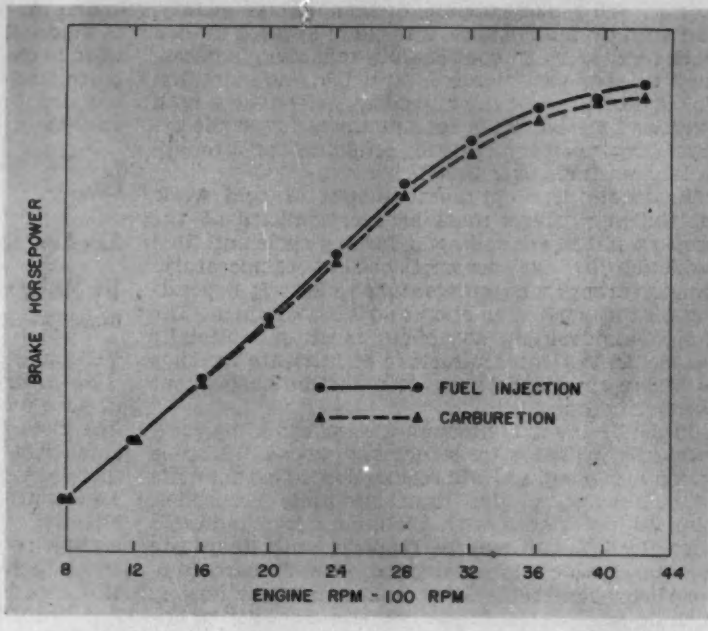


Fig. 1 — Brake horsepower data obtained with fuel injection and carburetion.

Fuel Injection . . .

just how good

Comparison of engine operation with method of metering the fuel the only variable shows that fuel injection has some benefits over carburetion, as far as performance and knock requirements are concerned.

Based on paper by

A. E. Felt, D. L. Lenane, and K. W. Thurston

Ethyl Corp.

COMPARISON tests of fuel injection and carburetion — on the same engine and, in so far as possible, with the method of metering the fuel being the only variable — produced the following conclusions:

1. There was a slight increase in brake horsepower with fuel injection, the increase varying from zero to a little less than 3%, depending on engine speed. This improvement was due to the elimination of manifold heat.
2. Fuel economy, as measured by brake specific fuel consumption, was the same with both systems across the manifold-vacuum and speed range of the engine when each system was operated to provide minimum specific fuel consumption.

3. Primary reference fuel requirements during full-throttle operation were the same with both systems at maximum-power fuel-air ratio and minimum spark advance for best torque at speeds above 1600 rpm. At 800 rpm, use of fuel injection reduced the requirement by 1.7 octane numbers.

4. Unleaded sensitive reference fuels tended to rate higher with fuel injection at 1600 rpm, and lower at 3200 rpm.

5. Leaded sensitive reference fuels rated higher at all speeds with fuel injection; the amount of the increased rating was dependent on tel concentration.

6. The effectiveness of tel in improving the antiknock quality of fuels was enhanced in this engine when fuel injection was used.

Since it was desired that each system be operated so that it gave optimum performance, the major portion of the program was performed on an engine dynamometer, where close control of operating conditions could be obtained. Other studies with a ve-

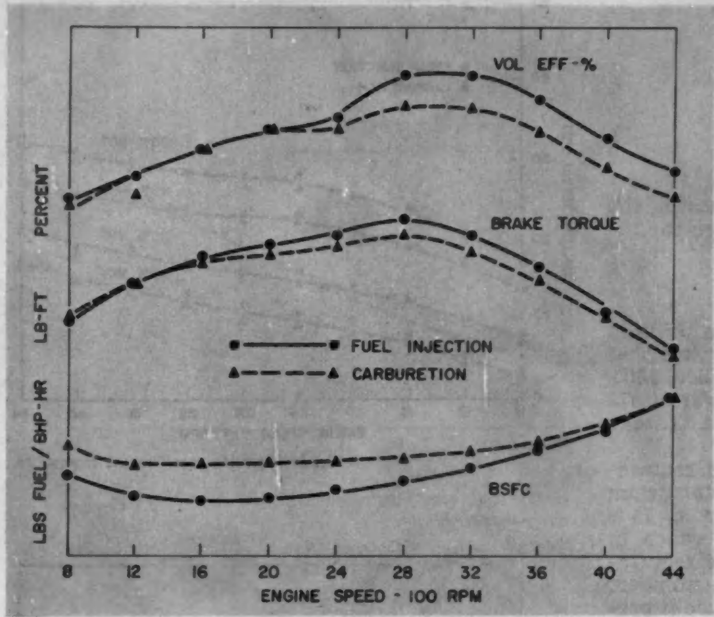


Fig. 2 — Volumetric efficiency, brake torque, and bsfc data obtained with fuel injection and carburetion.

is it?

hicle on the chassis dynamometer verified the dynamometer data.

Power and Economy

When determining power output, both fuel metering systems were operated at ideal conditions. The fuel-air ratios were adjusted to give best power, and ignition timing was maintained at the minimum advance for best torque (hereafter mbt). Full-throttle brake horsepower data are shown in Fig. 1. As compared with carburetion, the fuel-injection system produced some small gains in brake horsepower above 1200 rpm, amounting to 2.7% at 2800 rpm and 2.5% at 4400 rpm.

The improvement in power was accompanied by similar increases in volumetric efficiency and brake torque, as shown in Fig. 2. This improvement is probably due to the lower intake-manifold temperatures with the fuel-injection system and the elimination of the small drop in air pressure, and thus density, through the carburetor venturi. Brake specific fuel consumption during full-throttle operation was reduced by a maximum of 7.2% at 1600 rpm when the fuel-injection system was used, primarily because of the different fuel-air ratios at which best power was obtained with the two systems. With fuel injection, the power curve was essentially flat throughout a range of fuel-air ratios from 0.078 through 0.090. With carburetion, maximum power was achieved at a fuel-air ratio of 0.082, and the power began to fall off at a ratio of 0.090.

The mbt spark advance was essentially the same across the speed range for both systems, as shown in Fig. 3. However, the fuel-injection system required slightly more advance between 1600 and 2800 rpm, and slightly less advance between 4000 and 4400 rpm.

A comparison of part-throttle fuel economy as measured by brake specific fuel consumption is shown in Fig. 4. The values shown cover operation at manifold pressures ranging from 12 in. Hg absolute to wide-open throttle, and at engine speeds ranging from 800 to 3600 rpm. There was no benefit derived in changing from carburetion to fuel injection when both systems were operated at maximum-economy fuel-air ratios and mbt ignition timings. These constant-speed data should not be construed to imply that there can be no gain in over-the-road miles per gallon with fuel injection. There is a definite possibility of eliminating the accelerating pump and of accomplishing fuel cutoff during periods of deceleration with some fuel-injection systems. These changes could improve gasoline mileage, the amount of improvement being dependent on driving conditions.

Changing the time of injection relative to inlet valve timing had little effect on maximum power. However, engine operation was unsteady with late injection at low speeds and lean mixtures. Earlier injection improved low-speed performance and reduced the minimum brake specific fuel consumption over a wide range of speeds and loads. The best results were obtained by starting injection 135 crank-angle deg before the intake valve opened. Since the

Fuel Injection . . .

continued

injection period was 180 crankangle deg, most of the fuel was sprayed into the intake port before the intake valve opened.

Primary Reference Fuel Requirements

Octane-number requirements in terms of primary reference fuels were obtained for both systems at the fuel-air ratios for best power, and at 800, 1600, 2400, and 3200 rpm. The fuel-air ratios were 0.078 for fuel injection and 0.082 for carburetion. Intake air temperature was controlled at 100 F.

Fig. 5 shows the primary reference fuel requirements of the engine at mbt ignition timing when equipped with the two fuel metering systems. It is evident that there is no significant difference in requirements except at 800 rpm where the requirement with fuel injection was 1.7 octane numbers lower than with carburetion. This difference is presumably due to improved cylinder-to-cylinder distribution of the fuel. However, the full-throttle requirement at 800 rpm is largely academic in a car equipped with an automatic transmission. When the ignition timing was retarded from mbt for a 1, 2, and 5% power drop, the same relationship existed for requirements with the two different fuel metering systems.

Sensitive Reference Fuels

Four different series of sensitive reference fuels were investigated over the same speed range employed for the primary reference fuels.

Again, intake air temperature was controlled at 100 F and the fuel-air ratios were maintained at 0.078 with fuel injection and at 0.082 with carburetion. The sensitive reference fuels included the S series (blends of isooctane, heptane, and dib), the H series (blends of heptane, isooctane, and toluene), the B series (balanced blends of isooctane, heptane, dib, and toluene) and the 1955 series of CRC full-boiling range commercial reference fuels. The first three series were unleaded, but the CRC fuels contained 1.6–2.67 ml tel per gal, depending on the octane number. All four series had essentially the same sensitivity.

Fig. 6 shows engine rating of the S fuels obtained with carburetion and fuel injection at two different speeds, and compares these ratings with the Research ratings of the same fuels. There is a small but consistent tendency for these fuels to be rated higher in the fuel-injection engine at 1600 rpm and higher in the carbureted engine at 3200 rpm.

Fig. 7 shows ratings of the H fuels under the same conditions. Here again, the fuel-injection system tends to rate the fuels higher at low speed and lower at high speed.

Engine ratings of the B series of fuels are compared with Research ratings in Fig. 8. Again, the fuel-injection engine rated the fuels higher than did the carbureted engine at 1600 rpm, and lower at 3200 rpm.

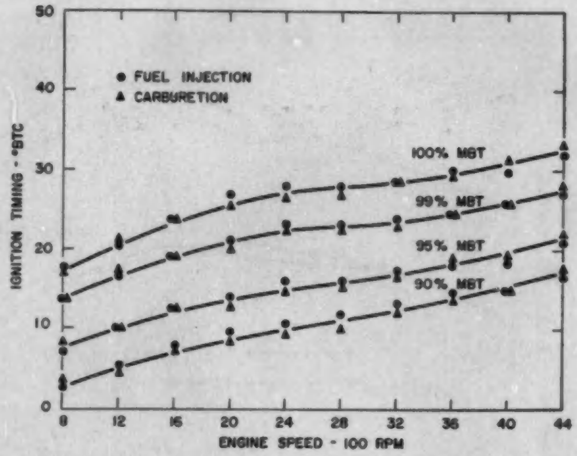


Fig. 3 — Ignition requirements comparison.

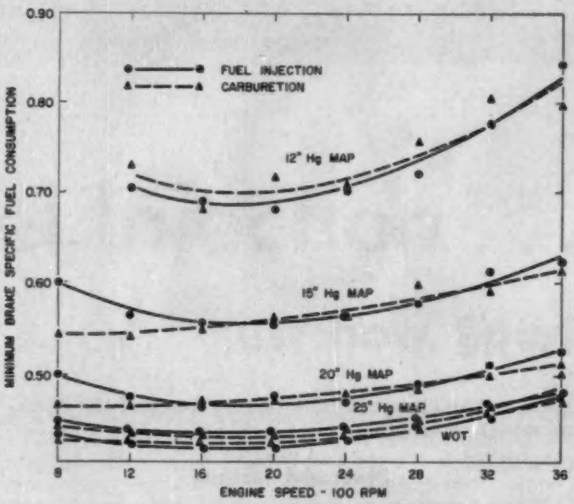


Fig. 4 — Fuel economy comparison.

There is an explanation for the tendency of these sensitive fuels to be rated higher with fuel injection at low speed and lower at high speed. First, fuels were rated at overall fuel-air ratios of 0.078 with fuel injection and 0.082 with carburetion. Also, it would be expected that cylinder-to-cylinder distribution of the fuel-air ratio with the carburetor would be considerably better at high speed than at low speed. A number of fuels were rated in the engine at fuel-air ratios ranging from 0.060 to 0.100 using fuel injection to insure that all cylinders were

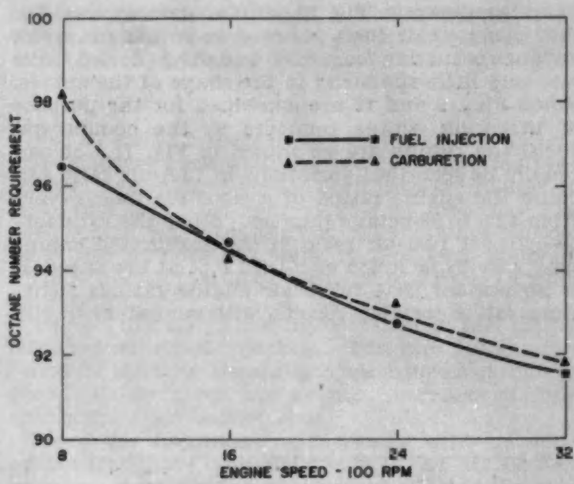


Fig. 5 — Primary reference fuel octane-number requirements.

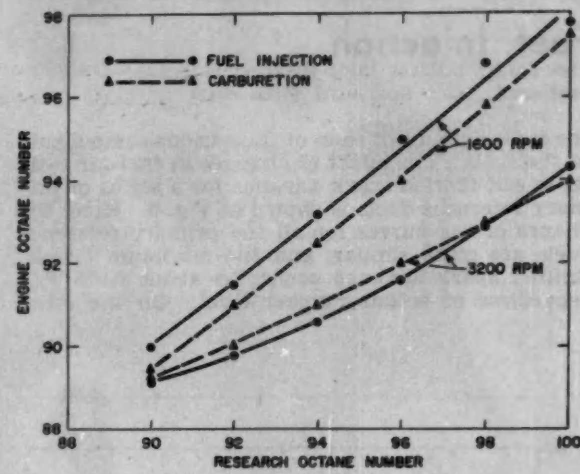


Fig. 6 — Fuel rating comparison — S reference fuels.

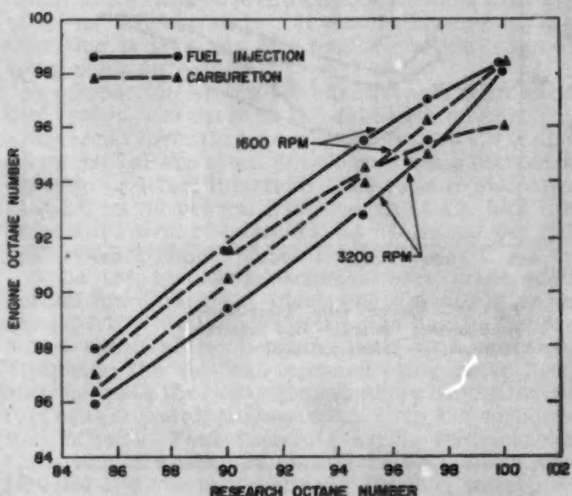


Fig. 7 — Fuel rating comparison — H reference fuels.

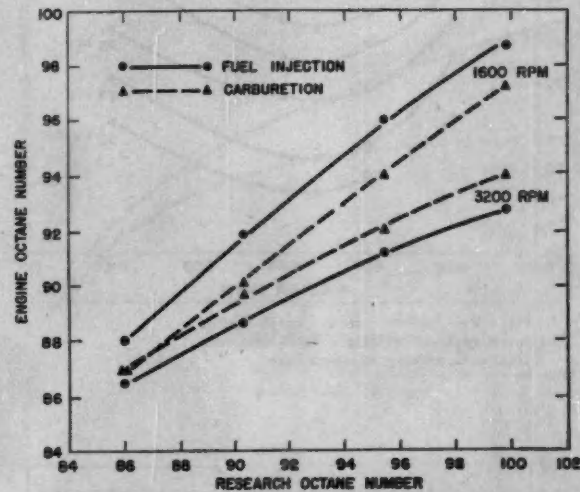


Fig. 8 — Fuel rating comparison — B reference fuels.

at the same fuel-air ratio. Among these were fuels of the H and S series. At 1600 rpm, a fuel of the H series having a Research octane number of 96, rated 94.6 octane number at 0.078 *F/A*, and 95.2 at 0.082. This is approximately the spread shown in Fig. 7 between the fuel injection (0.078) and carburetion (0.082) ratings of the H series of fuels at 3200 rpm, where good cylinder-to-cylinder distribution of fuel-air ratio would be presumed to exist with either system. At 1600 rpm, where cylinder-to-cylinder distribution of fuel-air ratio with the carbureted engine would not be as good, the higher ratings with fuel injection would occur if any one cylinder of the carbureted engine were running as lean as 0.070, even though the engine had an overall fuel-air ratio of 0.082. Such deviations from cylinder to cylinder would be expected at low speed.

The effects of changes in fuel-air ratio on knock-ratings of a number of fuels, some of which were blends of various hydrocarbons and some of which were commercial fuels, were studied using the fuel-injection equipment. With this equipment, it was assured that each cylinder was running at the same fuel-air ratio and that each cylinder was receiving

Fuel Injection . . .

continued

the same amount of each of the various components of the fuels. The effect of changes in fuel-air ratio on knock-limited spark advance for a series of primary reference fuels is shown in Fig. 9. Here, the shapes of the curves for all the primary reference fuels are quite similar, and the minimum knock-limited spark advance occurs at about 0.075 F/A regardless of octane-number level. On the other hand, as shown in Fig. 10, similar data secured for four commercial fuels resulted in minimum spark advance occurring from 0.065 to 0.072 F/A, and there was very little similarity in the shape of the curves. When Figs. 9 and 10 are combined for the purpose of assigning octane numbers to the commercial fuels, the results are as shown in Fig. 11. It can readily be seen that variations in fuel-air ratio can cause the engine rating of a sensitive fuel to vary from 92.6 to 98 octane number. Since the cylinder-to-cylinder fuel-air ratio in the carbureted engine may vary by as much as $\pm$ 0.020 F/A at low speed, it is no wonder that full-scale engine ratings sometimes fail to correlate exactly with laboratory single-

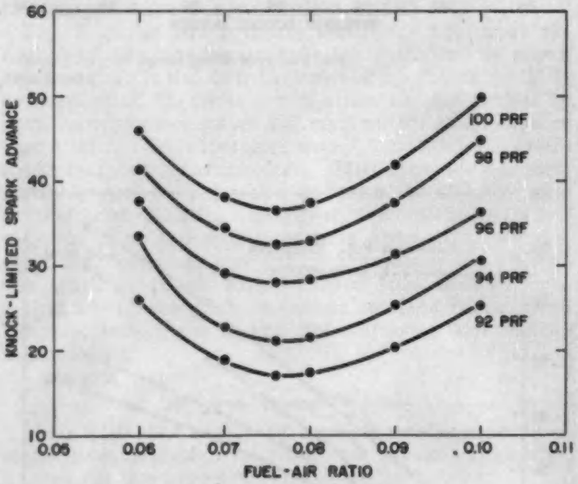


Fig. 9 — Fuel-air ratio knock-limited spark-advance effects. Fuel injection, 1600 rpm, primary reference fuels.

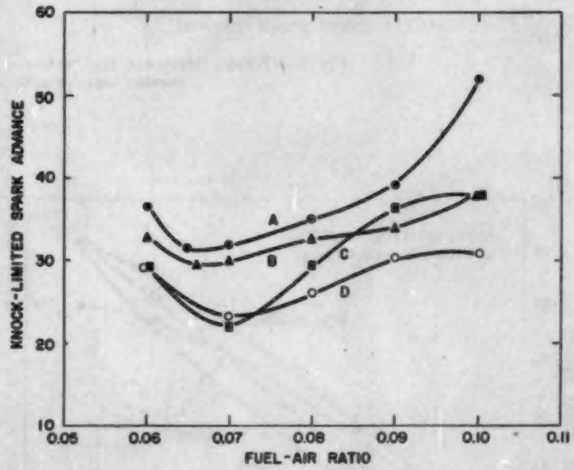


Fig. 10 — Fuel-air ratio knock-limited spark-advance effects. Fuel injection, 1600 rpm, four commercial fuels.

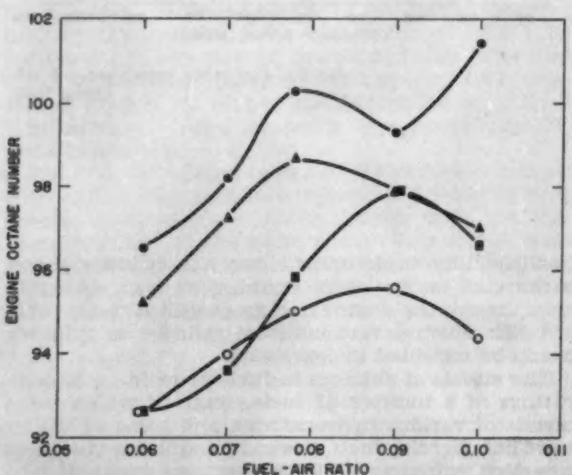


Fig. 11 — Fuel-air ratio octane-number effects. Fuel injection, 1600 rpm.

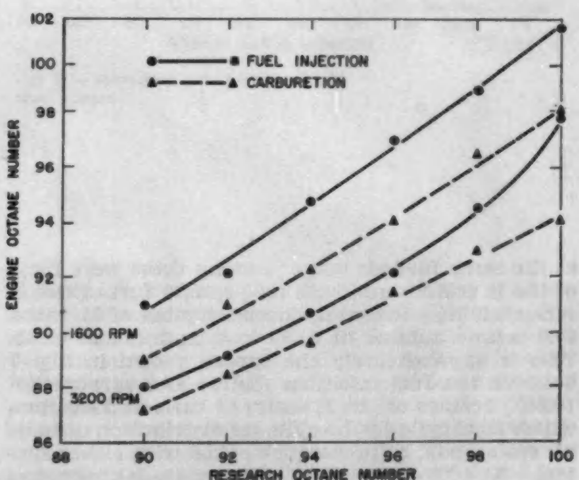


Fig. 12 — Fuel rating comparison. CRC C-55 reference fuels.

cylinder ratings. Although it is not implied that this is the only reason, it can certainly be an important and complicating factor.

Tel

Fig. 12 shows ratings of the leaded CRC commercial reference fuels with the two fuel metering systems at two engine speeds. Ratings were higher at both 1600 and 3200 rpm when fuel injection was used. This was also true at intermediate speeds. As in the previous test work, ratings were made at 0.078 *F/A* with fuel injection, and at 0.082 *F/A* with carburetion.

Table 1 illustrates the improvement in fuel rating obtained with fuel injection. The fuel designation numbers indicate Research octane numbers of the fuels. Values given are average increases at four speeds from 800 to 3200 rpm.

Since the improvement increases with tel concentration, these data suggest that the use of fuel injection improves the distribution of tel to the cylinders, as compared to carburetion in this engine. Therefore, use of this fuel-injection equipment on this engine could lower the concentration of tel required in a given base fuel to satisfy the engine requirement or would permit operation at a higher compression ratio or greater spark advance with the same tel concentration. It should be emphasized that this is true for *this* engine. Other engines could react differently.

A comparison of the tel effectiveness with each fuel system was made in the following manner. A commercial fuel with tel concentrations of 0, 1.0, and 3.0 ml per gal was rated at 1600 rpm using both carburetion and fuel injection. The ratings indicated that 1.0 ml tel per gal with fuel injection had the same antiknock effectiveness as 3.0 ml tel per gal with carburetion, as shown in Fig. 13.

Since the carburetion ratings were made with normal manifold heat, there was a question as to what part of the improvement was due to the reduced manifold temperature with fuel injection. Therefore, the test was repeated using other fuels and operating the fuel-injection unit with the manifold heat crossover passage open, as in the carburetion ratings. Four fuels of varying hydrocarbon type, each of which had normal distillation characteristics and was commercially feasible, were prepared with tel concentrations ranging from 0 to 3.0 ml per gal. The fuels were blended so that they approximately satisfied the requirements of the engine with the intermediate tel concentration of 1.5 ml per gal. These fuels were rated at 1600 and 3200 rpm with each fuel system. As shown in Fig. 14, average data for the four fuels revealed that 1.25 and 2.0 ml tel per gallon with fuel injection are equivalent to 2.0 and 3.0 ml tel per gal, respectively, with carburetion at 1600 rpm. At 3200 rpm, the averages indicate that 1.6 and 2.2 ml tel per gal with fuel injection are equivalent to 2.0 and 3.0 ml tel per gal, respectively, with carburetion.

These data show that, in this engine, fuel injection improves tel effectiveness over a wide speed range. This improved effectiveness is presumably due to improved distribution of tel from cylinder to cylinder.

To Order Paper No. 3B . . .
. . . on which this article is based, turn to page 5.

Table 1—Improvement in Fuel Rating Obtained with Fuel Injection

Fuel	Tel, ml/gal	Octane-Number Improvement with Fuel Injection
100 C	2.67	3.1
98 C	2.39	1.5
96 C	2.10	1.3
94 C	1.84	1.0
92 C	1.60	0.7

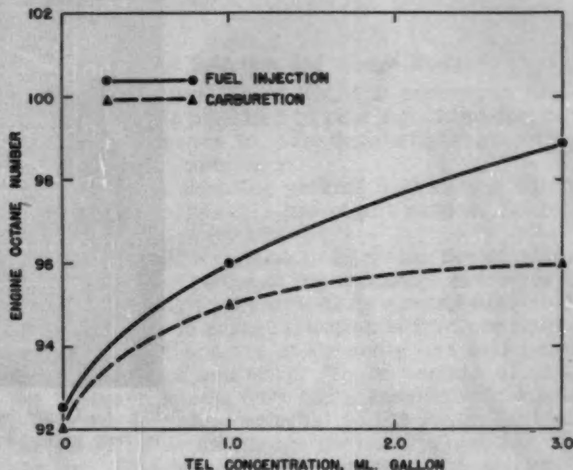


Fig. 13—Tel effectiveness. One commercial fuel, 1600 rpm.

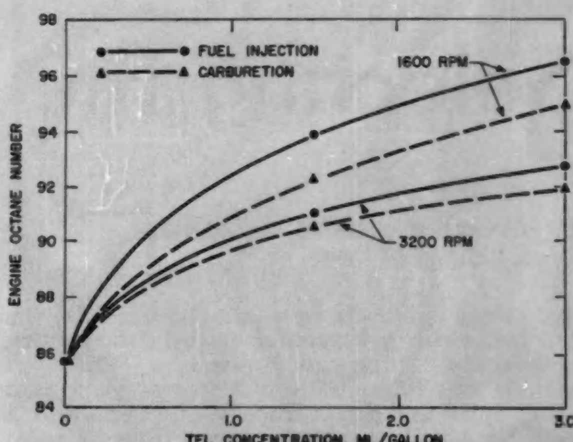


Fig. 14—Tel effectiveness. Average of four commercial fuels.

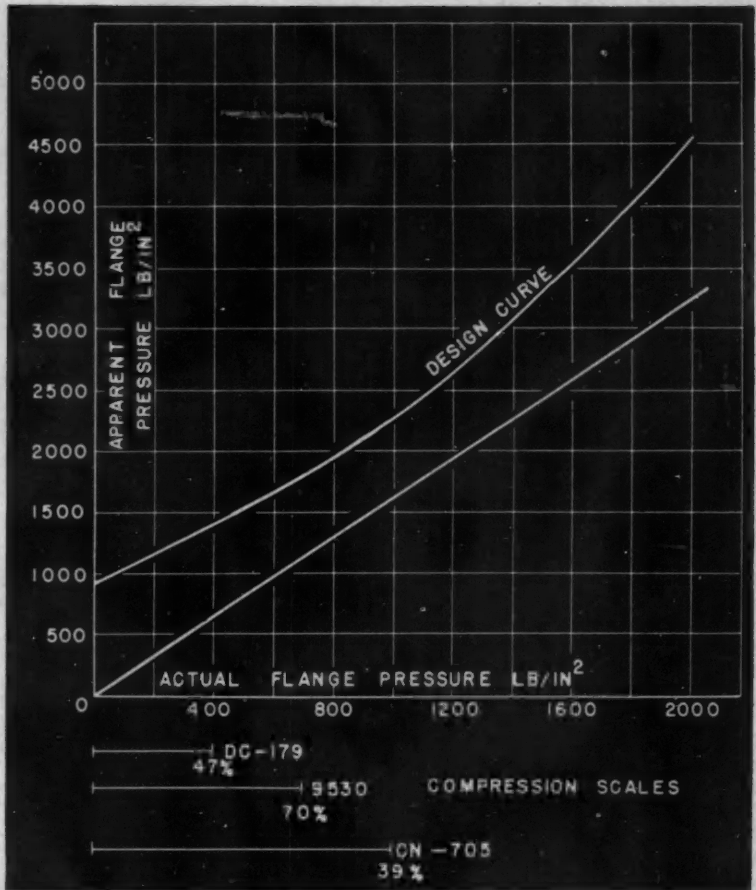


Fig. 1—Chart by which bolt torques on a joint assembly can be translated to true gasket loads.

A New Tool for use in Selecting the Right Gasket

Based on paper by

E. M. Smoley

Armstrong Cork Co.

BY use of a recently developed chart (Fig. 1) the designer can get considerable help in selecting gaskets for existing flange assemblies. The chart permits him to translate bolt torques on a joint assembly to true gasket loads. Thus, it provides a basis for determining the minimum loads which, in many cases, are the practical criteria of sealability.

Here's how the chart can be used, for example, to get true gasket loads on a flanged assembly like the one shown in Fig. 2. In the field of low internal pressures, this assembly is commonly used for sealing oil, gasoline, water, steam, and other media. Some examples are the flanged joints on automotive pumps, rocker arm assemblies, oil pans, and oil pumps. Generally speaking, the gaskets employed are made from cork composition, cellulose fiber, and asbestos fiber, combined with varying proportions of rubber.

Flange loads can be estimated from known torque settings on the bolts. But flange loads based on bolt torques are different from actual loads on the gasket, because of the frictional characteristics of

the mating threads. This chart (Fig. 1), however, reconciles this difference, thereby permitting the designer to translate bolt torques on a joint assembly to true gasket loads. This figure is applicable to any design of the type illustrated, but only if certain rather broad conditions are imposed on the design to minimize frictional variations in bolt efficiency.

Flange pressures calculated from known bolt torques are plotted along the vertical scale. Because they do not represent true or actual gasket loading conditions, they are called "apparent" flange pressures—to distinguish them from the actual flange pressures plotted along the horizontal axis.

To calculate an apparent flange pressure for a particular joint assembly, bolt torque has to be converted to bolt load. An approximate equation suitable for the purpose is:

$$T = 0.2DL$$

where T = torque, lb-in.; D = nominal bolt diameter, in.; and L = bolt load, lb. The sum total of all bolt loads on a design having been found, the calculation follows the simple formal procedure for finding a load per unit area; that is, the total load divided by the gasket-flange contact area. The flanges, of course, must not distort under the bolt loads.

Actual gasket loads vary, of course, with variations in bolt efficiency. So, the apparent flange pressure calculated for a design cannot be related to just one actual flange pressure value. Instead, it is possible to speak only in terms of a range of actual values. The lower limit of this range is obtained from the design curve of Fig. 1; while the upper limit is the apparent value itself. Suppose the apparent value is 1375 psi. The actual flange pressure falls somewhere in the range extending from 400 to 1375 psi. By recognizing certain thread conditions one could guess in which half of the range the actual flange pressure is most likely to be.

Rough, dry, or slightly rusty screw threads are conducive to low bolt efficiencies; consequently, under such conditions the actual gasket loads will most likely fall in the lower half of the range, because much of the bolt torque is consumed in overcoming thread friction. On the other hand, if the threads are oiled or greased, bolt efficiencies will tend to be relatively high. Result: actual gasket loads will more than likely shift to the upper half of the range.

The straight line of the graph of Fig. 1 gives another actual flange pressure value which roughly coincides with the mid-point of the range as described above. For this reason it could be referred to as a most probable value.

Minimum Sealing Loads Required For Gaskets

The compression scales below the graph in Fig. 1 are designed so that the minimum sealing load specified for a gasket can be used in connection with the above method of estimating gasket loads. To avoid crowding, only three gaskets are shown in Fig. 2; each represents one of a general class. From current information, however, it is possible to list a variety of gaskets capable of meeting almost any service requirement in the field of low internal pressures.

The minimum sealing compression for a material is given by the last compression value on its compression scale. Vertically above this final value the minimum actual flange pressure for sealing can be found on the actual flange pressure scale. For example, 47% is the minimum compression for DC-179; by reading directly above, it is seen that a minimum of 400 psi actual flange pressure is required to get that much compression.

It should be understood that a seal point is a minimum loading condition—not a point of overload. It must be equalled or exceeded. Higher loads will usually result in tighter seals. If for some reason it is mandatory to impose greater loads on a gasket than are recommended in Fig. 1, no harm can be done to the gasket as long as the loading is distributed uniformly. In fact, the rupture points for the materials listed in Fig. 1 range upward from 4000 psi on the actual flange pressure scale.

Gasket Selection and Flange Design

In practice the use of Fig. 1 is somewhat arbitrary. It is not intended to be a substitute for, but rather an adjunct to, the designer's engineering judgment and experience.

As an aid in selecting gaskets for existing flange assemblies one possible use might proceed as follows:

From the bolt torque settings on the design along with Fig. 1, the range of actual flange pressures is found according to the procedure already discussed. The idea basic to gasket selection is that the flange assembly must operate at or above the seal point for the selected material. To be certain of this, the designer selects only those gaskets whose seal points are less than or equal to the lower limit on the range of actual flange pressure values for the design. This amounts to assuming the assembly contains bolts of low efficiency, thereby producing

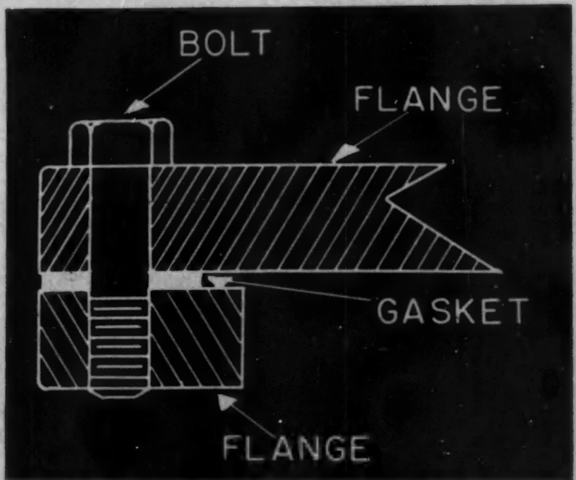


Fig. 2—Sample flanged assembly on which true gasket loads may be calculated by use of chart in Fig. 1.

A new tool for use in selecting the right gasket

continued

gasket loads near the lower limit on the range of actual values. But such efficiencies are rarely encountered in practice. Usually they are higher. The result is a high degree of certainty that the flanged assembly will operate above the critical sealing load for the gasket.

In design the same basic ideas apply. Here the problem is one of finding the number of bolts, their size and torque setting so that the actual flange loads will never be less than the sealing minimum for the gasket. There are three general considerations involved.

1. Suppose the flange loading on an assembly is to be designed around the DC-179 gasket whose minimum sealing compression is 47% and minimum actual flange pressure is 400 psi. In accordance with the previous discussion, the 400-psi seal point must be taken as the lower limit on the range of actual flange pressure values for the proposed design. The design calculations are then based on an apparent flange pressure of 1375 psi which is obtained from the design curve of Fig. 1. Assuming the gasket-flange contact area of the proposed design is 12 sq in., the total apparent load in pounds is:

$$12 \times 1375 = 16{,}500$$

2. The total apparent load must be divided equally among the number of bolts selected. It is almost impossible to give clearcut general rules on determining the number of bolts required, because in the field of low internal pressures there are too many variations in the basic flange design under consideration. For the problem in question assume that eight 1/4–20 NC mild steel bolts are sufficient to carry the load without causing flange distortion. Each bolt must carry about 2063 lb. The torque (in pound feet) is readily found as follows:

$$\begin{aligned} T &= 0.2\,DL \\ &= 0.2 \times 0.250 \times 2063/12 \\ &= 9 \text{ (approximately)} \end{aligned}$$

3. Torque values must not be so high that there is a possibility of bolt yield or breakage. If so, the bolt number is increased; if the number cannot be changed then the next larger bolt size must be selected. Table 1 gives a rough idea of the torque limits for some of the bolts found in the field of low internal pressures.

These limits apply to mild steel bolts (per cent carbon 0.15–0.25). As the steel becomes harder the limits can be increased accordingly. The table shows that the 9 lb-ft of torque on a 1/4–20 NC mild steel bolt is satisfactory. In summarizing then, the 9 lb-ft of torque on each of the eight 1/4–20 NC bolts should produce an actual flange pressure of no less than 400 psi, the seal point for the DC-179 gasket.

Pressures from Gasket Compressions

Obviously the range of actual gasket loads for a given torque setting is rather wide. However, if on an existing flanged assembly a more accurate estimation of actual flange loads is necessary, then it is suggested that solder plug techniques be employed.

Conditions of Applicability For Chart

In order that actual gasket loads be determined from bolt torques and Fig. 1, certain conditions must be imposed on the flanged assembly:

1. Mating screw threads must be free of lock nuts, wrench tight fits, and various types of plating.
2. Bolts must be no softer than mild steel; aluminum or brass is not acceptable. Mild steel bolts threading into cast iron are satisfactory.
3. Lock washers or any other device which may give rise to a high coefficient of friction between the bolt and flange must not be used.
4. Flanges must distribute their bolt loads uniformly over the gasket. Solder plug techniques can be used as a test for determining whether or not a flange assembly is distributing its loads uniformly.
5. Bolt sizes can range from 1/4–20 NC to 3/4–10 NC. The fine thread series is also acceptable.

Basis for Chart (Fig. 1)

Fig. 1 is based on results obtained from a number of flanged assemblies selected from the field of low internal pressures. They included automotive rocker arm designs, automotive water pumps, compressor-head flanges and others.

The curves of Fig. 1 are a result of a statistical correlation study between the apparent and actual flange pressures. The straight line is the statistical least squares line and the curved line can be considered a confidence curve based on a probability level and the variability of the data. Furthermore, the confidence curve is also associated with low bolt efficiencies. Bolt efficiencies were studied by electromechanical strain-gage methods.

To Order Paper No. 13A . . .
. . . on which this article is based, turn to page 5.

Table 1—Torque Limits for Bolts used in Field of Low Internal Pressures

Bolt Size	Maximum Torque, lb-ft
1/4–20 NC	10
5/16–18 NC	15
3/8–16 NC	30
7/16–14 NC	45
1/2–13 NC	60
9/16–12 NC	85
5/8–11 NC	130

A feature of the

SAE Nuclear Energy Advisory Committee

Interplanetary travel . . .

. . . will require nuclear propulsion, such as the conventional nuclear rocket, atomic recoil propulsion, or the ionic drive described here briefly.

Reported by

T. F. Nagey

Member, SAE Nuclear Energy Advisory Committee

INTERPLANETARY travel, according to most rocket experts, will require some form of nuclear propulsion. Among the nuclear systems that have been suggested are the conventional nuclear rocket, atomic recoil propulsion, and the ionic drive. All of them will require considerable technological progress in both nuclear and associated fields before they become practical.

Conventional Nuclear Rocket

One of the most promising systems for ready development, despite present shortcomings, is the nuclear rocket, in which the oxidizer is replaced by a reactor. In this propulsion scheme, a fuel—a good one would be liquid hydrogen—is used as the reactor coolant, which becomes heated and is ultimately ejected at high velocity. The practicality of this system for extended planetary travel seems to be limited, due to the difficulty in storing and transporting the hydrogen for extended periods of time. It does appear to offer potential for short-duration flights, such as to the moon.

The energy required from such a reactor would have to be on the order of 4000–5000 megawatts (227–284 million Btu per min). This power requirement is rather high when compared to reactors currently under consideration. Though power level is important, the temperature required by this system is equally important. For example, even for a relatively small, well-designed rocket, the temperature rise required of the hydrogen fuel would be on the order of 2300–3200 F. Of course, the reactor heat transfer surface must be at a much higher temperature than this. It is not difficult to visualize the magnitude of the engineering problems associated with temperatures of this order. Even when using high-temperature materials such as uranium carbide (melting point, 4036 F), the construction of a reactor such as this would be an extremely difficult problem. The engineering limitations of this system may be extended if a consumable reactor proves feasible, and the powered flight time requirement is maintained within a few hundred seconds.

Atomic Recoil Propulsion

Assuming a vehicle is in outer space, several proposals suggest propulsion would be possible by recoil momentum provided by fission fragments associated with a nuclear reaction or by particles ejected during the decay of radioisotopes. Fission fragment propulsion is extremely difficult to visualize for many reasons, among them is the unique interrelationship between reactor geometry and criticality.

The possibility of propulsion by decay particles is somewhat enhanced by the fact that radioisotopes could be placed in an extremely thin layer on a large surface which, when exposed in the vacuum of outer space, would act as a sail for the recoil supplied by the ejection of decay particles, thus driving the vehicle. Using the radioisotope polonium for this application, a sail with an area of about 200 sq ft could accelerate a mass of 22.4 lb at an average rate 10^{-5} g during its 138-day half-life.

These propulsion schemes are admittedly exotic and considered impractical.

Ionic Drive

Probably the most intriguing ideas revolve around the possibility of all-electrical rocket propulsion systems. One system being considered involves the use of a rather small nuclear reactor to drive a turboelectric generator. The electric energy would be used to accelerate ions and electrons in a thrust chamber (acceleration grids). The propellant required in this particular system must have a high atomic mass, coupled with a low ionization potential. Several papers report that such an ion propulsion rocket can be expected to extract approximately fifty times more impulse than a chemical rocket. These papers also indicate that the reactor power required is 50–100 megawatts. The biggest deterrent to a successful application of ionic drives is not the reactor per se but in problems associated with elec-

trical generating equipment. Present equipment is so heavy that it limits rocket performance severely.

A better approach to this problem of weight—and at the same time more conjectural—lies in the development of thermoelectric conversion devices; that is, methods for obtaining electrical power directly from the reactor without the intermediate thermodynamic cycle and its attendant complex of electrical generating apparatus. These schemes range from operating a pressure wave against a magnetic field in a fusion-plasma device to utilizing the solid-state properties of semiconductors.

A recently announced device, called a thermoelectron engine, utilizes a temperature gradient between two plates with a consequent flow of electricity. The engine has demonstrated efficiency of about 12%. This efficiency at such an early stage in the development is extremely gratifying inasmuch as normal steam-electrical power plants report efficiencies slightly over 25%. The promise of this approach is further bolstered by a forecast that an efficiency of 30% can be eventually achieved. Apparently, a powerplant using this principle could be built to yield as much as 15 kw per cu ft of volume. On the other hand, a conventional plant of the very best design has a capacity of 0.3 kw per cu ft.

Obviously, if a development such as the thermoelectron engine meets its promise, the use of an ionic drive with direct conversion offers a desirable direction for space travel.

"Different" Station Wagons . . .

. . . visioned in foreseeable future. Rear-engines, club-car seating, roll-top roofs—even cooking facilities are in designers' minds. Overall length of 180 in. can accommodate 9 people with ease.

Excerpts from paper by

D. C. Woods,
Ford Motor Co.

STATION wagons of the future may be very different from those we have today. With the station wagon market now over 500,000 units a year, someone may divorce its design completely from the regular car line. They might then bring out a model designed *strictly* for large capacity, good appearance, dependability, and ruggedness.

One such type could be similar to the European small, rear-engine designs which allow a maximum number of people to ride in minimum overall dimensions. An overall length of 180 in. can accommodate nine people with ease, if the driver sits over the front wheels.

Another type would be a pickup truck variation similar to the present Ford Ranchero but with a removable or a canvas folding top to give protection to passengers. The new International line has a combination car-truck called the Travelette, where the passenger-car portion seats five and six people comfortably and yet still allows a small pickup bed to be placed behind the car body.

Unique seating arrangements will be explored, such as the ubiquitous club car seating, where the rear passengers sit in a semicircle, as in a railroad observation car. This has always been impossible in a conventional passenger car, because of width limitations as well as the presence of the drive shaft and rear axle. With a rear-engine model this might be possible with the increased body widths becoming more popular.

In combination with this club car seating we could have a forward driver station wagon where the driver is alone and back of him is a semicircular lounge seat which could hold six or seven people. That, plus the driver, would give the same seating capacity that we have today but a much more unique arrangement of passengers. Another type would be fully swivelling seats where the passengers could face to the rear, to the front, or any direction, so as to vary their attitude on a long cross-country trip.

As for exterior appearance, we will certainly be seeing sliding or roll top roofs, the sliding panels going back into the roof, the roll top being similar to the old roll top desks where aluminum or lightweight plastic strips retract into a center roller. Or we could have swing up sides for easy accessibility and also entrance and exit. These would be pivoted at the top and break through the middle at the belt line. This was an arrangement shown on a General Motors show car a few years back called L'Universelle, which had many fine design features. Finally, the ultimate in station wagon design would be what we could call a transcontinental cruiser which would be equipped with bunks, tables, and all the manifestations of a living room on wheels: built-in television, cooking facilities, plumbing, in other words a trailer built into a car on a somewhat modified scale so that everyone could be together on a trip and yet enjoy the comforts which can be found in a trailer.

The station wagon is no longer connected exclusively with the station, nor is it by any means a wagon. In its flexibility and spaciousness it most nearly fills all the needs of the typical American family. In the future new names will supplant station wagon, and I submit what I think it will become, "The Second Home."

To Order Paper No. 27A . . .
. . . on which this article is based, turn to page 5.

Radioactivity Traces Piston-Ring Wear

Based on paper by

J. S. Batzold, J. V. Clarke, Jr., and J. F. Kunc

Esso Research & Engineering Co.

CONTINUOUS monitoring of lubricating oil in a car containing radioactive rings provides a better understanding of the factors governing piston-ring wear in passenger-car engines. A recent radiotracer study reveals:

1. Under conditions of low jacket temperature, very severe piston-ring wear has been found to occur due to corrosive action by products of combustion.

2. The magnitude of low-temperature ring wear is influenced by fuel components capable of producing corrosive materials upon combustion.

3. Present day compounded motor oils are effective in reducing low-temperature ring wear. Zinc dialkyldithiophosphate additions, however, had no effect on the amount of ring wear obtained.

4. Wear rates under normal jacket-temperature conditions are very low.

5. Some, but not all, rust preventives are effective in reducing low-temperature wear.

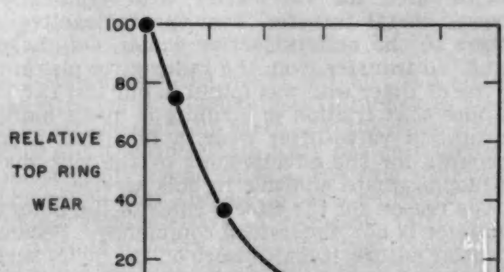


Fig. 1—Top ring wear increases with decreasing jacket temperature.

Wear Greatest at Low Jacket Temperature

The effect of jacket temperature on the rate of top ring wear was studied at continuous idle. Here, the jacket temperature was kept at the desired level by adding a controlled amount of cold water to the cooling system. The range of jacket temperature studied was between 60 F and 150 F, using an SAE 10W-30 mineral oil in the crankcase and a leaded gasoline containing 0.045% sulfur as fuel.

As the jacket temperature was reduced below 110 F, the rate of wear increased markedly. As shown

Table 1—Effect of Fuel Additives on Ring Wear at 70 F Jacket Temperature (Commercial 10W-30 Lubricant)

Additive in Iso-octane	Relative Wear Rate
None	100
1 Theory Ethylene Br_2 [a]	150
1 Theory Ethylene Cl_2 + 1/2 Theory Ethylene Br_2 [a]	180
0.05% Sulfur	460
3.0 ml tel/gal [b]	120

[a] No lead present; concentration based on hypothetical 3 ml tel/gal

[b] As aviation mix (tel + 1 Theory Ethylene Br_2)

in Fig. 1, the wear rate at 60 F was ten times as high as it was at 110 F.

The sensitivity of the ring wear rate to jacket temperatures below 110 F suggests that a chemical mechanism is responsible for this wear. One explanation that fits the data obtained in this study is that water and fuel-derived inorganic acidic materials (SO_2, SO_3, HCl, HBr, and such), formed as products of combustion, are able to condense on the ring surfaces at low temperatures causing corrosion which ultimately results in loss of metal or wear. In this connection, it is of interest to note that the jacket temperature at the inflection point of the curve in Fig. 1 approximates the dew point of the combustion gases which is in the range of 130 to 135 F.

To test the postulate of chemical attack, a number of fuels were used in the engine under conditions of continuous idle, where the individual fuels could be burned in sequence without any engine shutdowns. The work was performed at a controlled low jacket temperature (70 F), using as fuel iso-octane both alone and containing sulfur, tel, and lead scavengers. Concentrations were chosen to approximate the amounts encountered in typical gasolines. The data obtained are shown in Table 1. On the basis of these results, low temperature ring wear appears to result from attack in the ring area by corrosive materials formed as products of fuel combustion.

Table 2—Little Advantage for Lubricant Additives under Highway Driving Conditions (50 to 55 mph)

Lubricant	Relative Wear rate
Base oil	100
Commercial 10W-30 oil	85

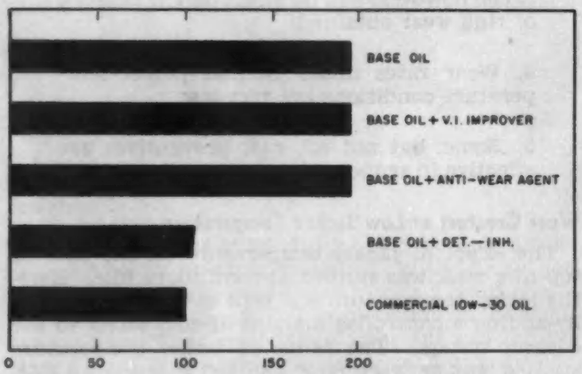


Fig. 2—Detergent inhibitor reduces startup wear.

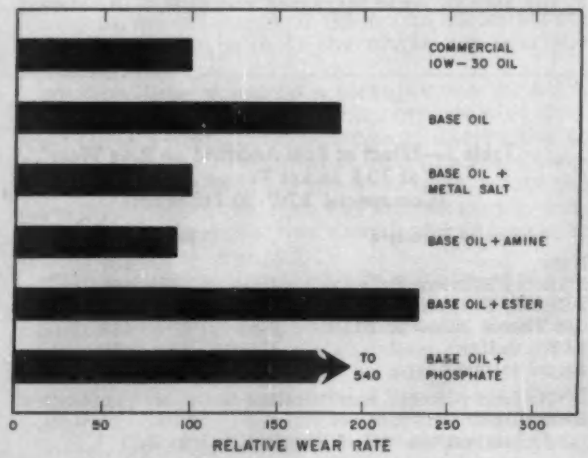


Fig. 3—Some rust preventives reduce startup wear.

Conventional Detergent-Inhibitor Additives Reduce Start-Up Wear

The additives normally used in compounding a representative SAE 10W-30 motor oil were evaluated separately for their effects on ring wear. These additives included a detergent-inhibitor, V.I. improver, and zinc dialkyldithiophosphate which is used both to reduce valve train wear and as an inhibitor for oxidation and bearing corrosion.

Fig. 2 shows that the detergent-inhibitor was the only additive that had any effect on start-up wear at low temperature. The presence of the V.I. improver or the zinc dialkyldithiophosphate had no effect on the amount of ring wear obtained.

The failure of zinc dialkyldithiophosphate to reduce wear under low-temperature operating conditions is in contrast with some other studies on piston ring wear and with results obtained in valve-lifter wear studies where this same additive has proven very effective in reducing wear. Apparently, the mechanism of piston-ring wear at low temperatures is quite different from the mechanism operating at the higher temperatures studied by others and also different from that operating between valve lifters and the cam lobes.

Further evidence of this latter difference is illustrated by autoradiographs of the camshaft from an engine used for valve-lifter wear studies which showed metal transfer from the radioactive valve lifters to the nonradioactive cams. On the other hand, no transfer from the radioactive piston rings to the cylinder wall was found in our test car. This implies that friction or scuffing is much more important in valve-lifter wear, a fact that probably accounts for the effectiveness of the zinc dialkyldithiophosphate additive in this service.

The reason for the effectiveness of the detergent-inhibitor is not understood completely. Because of its polar nature, it may adsorb on the metal surfaces and provide a stronger protective coating than the base oil itself. It is well known that materials of this type are capable of preventing rust formation, at least under certain conditions. Acid neutralizing power alone is probably not sufficient to provide protection, based on results obtained by injecting an acid neutralizing material, ammonia, into the cylinders on shutdown.

It was found that ammonia injection, in combination with the use of oil containing detergent inhibitor, reduced the wear some 40% below the detergent oil alone. However, in the absence of any detergent-inhibitor in the oil, ammonia addition had absolutely no effect on the wear rate. Thus, while acid neutralization may play some part in corrosive wear reduction, some other property of the detergent-inhibitor, perhaps film formation, appears to be controlling.

Conventional Additives Show Small Advantage Under Highway Operation

Wear rates obtained under highway operation (steady 50-55 mph driving) are much lower than for startups at low jacket temperature. The amount of iron worn off the rings in one engine start at 70 F jacket temperature was found to be approximately equivalent to the amount worn off in 10 miles of highway driving. Data have been published which imply that a large part of the wear associated with this type of operation must be due to abrasives, and only a small amount due to friction wear. This may explain why only a small and perhaps insignificant benefit was found for the presence of conventional additives under highway driving conditions as shown in Table 2.

If most of the wear occuring at the higher jacket temperatures is indeed due to abrasives in the oil, it is difficult to see how much reduction can be obtained from improvements in lubricants. More efficient filters, combined with frequent oil changes, have the best chance of minimizing abrasive wear.

It should be emphasized that the detergent inhibitor contained in the 10W-30 oil referred to in Table 2 is effective in reducing wear under the operating conditions where the wear rate is greatest, namely at conditions of low jacket temperature.

Some Rust Preventives Reduce Startup Wear

A number of conventional materials known to inhibit rust formation under various conditions were tested for their effects in controlling startup wear. These materials can be classified into four main types:

1. A metal salt of an oxidized petroleum fraction
2. An amine
3. An ester
4. A phosphate

Fig. 3 shows that the metal salt and the amine were as effective as the detergent-inhibitor in their ability to reduce start-up wear. On the other hand, the ester and the phosphate were not only ineffective, but actually detrimental in the ring wear test.

A phosphate very similar to the one tested here was found very effective in reducing valve train wear. This is another indication that completely different mechanisms are involved in low-temperature piston-ring wear and valve-train wear. The effective materials probably act by the same mechanism as the detergent-inhibitor, most likely by adsorption on the metal surface to provide a protective film.

To Order Paper No. 16C . . .
. . . on which this article is based, turn to page 5.

Test Equipment

A passenger car equipped with an overhead valve V-8 engine was used to obtain the wear data described in this article.

Two engine modifications were made:

1. The full-flow oil filter was bypassed since the filter would trap radioactive debris, and prevent all the activity in the oil from being counted. Frequent oil changes (150 miles maximum) were used to minimize any effect of abrasive wear resulting from solid material that would normally be filtered out of the oil.

2. The chrome-faced top rings usually used with this engine were replaced by cast iron rings. By a two-week exposure to neutrons, cast iron rings, each of which contained approximately 1.5 millicuries of Fe^{59}, were obtained. After installation, the head and block provided sufficient shielding to keep the radiation intensity far below hazardous limits.

A cylindrical counting well, shielded with lead 2-4 in. thick, was mounted on the floor of the rear passenger compartment. The 4-in. shielding was located on the side of the counting well which faced the engine block to reduce the background due to irradiated rings. Lubricating oil was circulated through the well by means of a pump situated in an oil line leading from the bottom of the crankcase. The inlet stream to the counting well came directly from the bottom of the oil pan, and the equipment was such that the total oil charge circulated at least once every 30 sec. This was enough agitation to minimize any effects of settling of radioactive debris.

An aircooled scintillation tube placed in this counting well was connected to a ratemeter and a recorder. When the car was operated over the road, a 2.5-kw motor generator, towed behind the car in a trailer, supplied electrical power to run the counting equipment. Thus a continuous record of piston-ring wear could be made as the car was run either in the laboratory or on the road.

The validity of the continuous counting method was spot checked by removing samples of the used oil of known volume during the course of the tests and determining the amount of radioactive iron using the scintillation tube and a scaler.

The weight of iron in a given sample of used oil was calculated using a standard solution containing a known amount of active piston-ring material. The standard solution was always made up from a piece of piston ring which had been irradiated along with the eight rings normally used in the engine.

Mid-air crashes can be stopped if airplanes use Cooperative Collision Detection

Based on paper by

Y. J. Liu and J. O. Campbell

Aerosystronics Corp.

Why use a Cooperative-Collision-Avoidance System

- Greater range because only one-way signal transmission needed.
- Cheaper, lighter, and smaller.
- Shorter range required because both planes turn.
- Only forward approaching aircraft must be detected. Overtaking planes execute the collision-prevention maneuver.
- Simple computing requirements.
- Slow (private) planes need only a small portion of the complete system.
- Useful in traffic control at airports.

A COLLISION-avoidance system (CAS) designed by Aerosystronics warns of danger when the relative velocity vector of two aircraft and their line-of-sight direction are coincident. An avoidance turn is made by one or both aircraft after altitude, speed, and heading information is computed from signals transmitted by both planes. The turn may be manual or automatic.

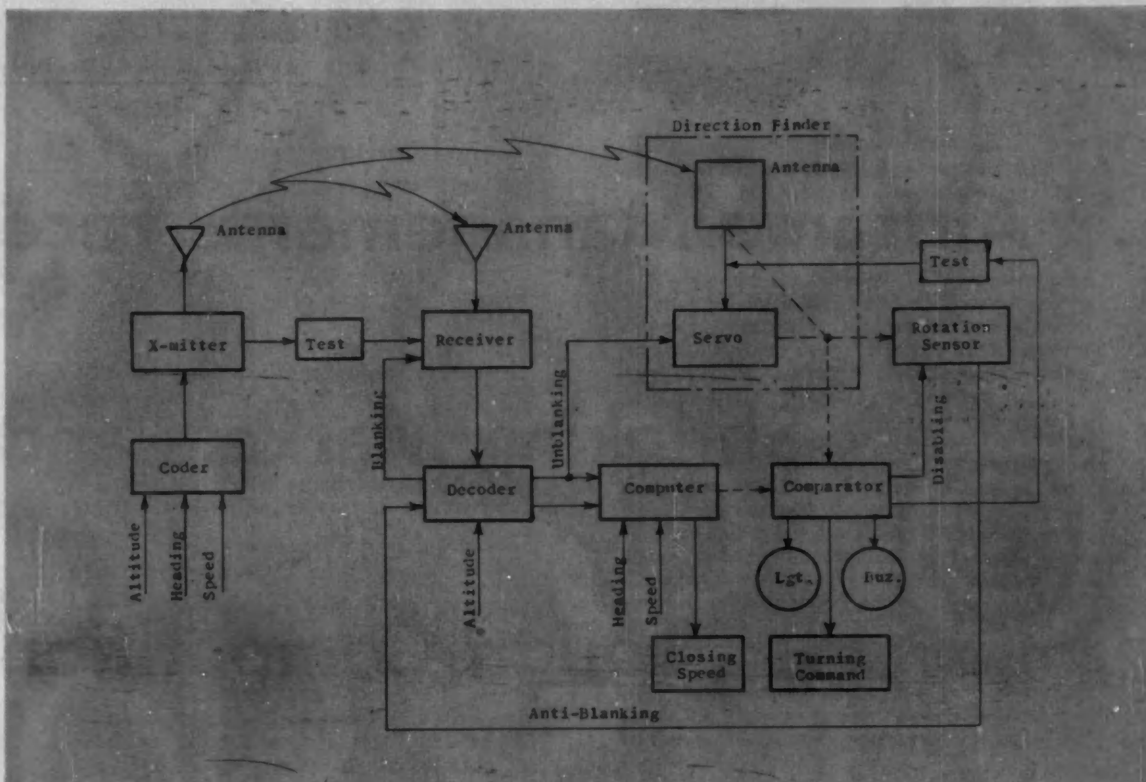
CAS Broadcasts Flight Information

Each airplane broadcasts coded information on its altitude, speed, and heading at a fixed repetition rate. This information is gathered from the plane's pressure altimeter, pitot tube, and compass. An approaching plane picks up the signal with a dipole and a direction finding antenna. The first antenna is used to compute the relative velocity vector and the second to fix the line-of-sight direction.

The block diagram shows that the altitude information is first compared at the decoder. If the planes aren't at the same level the rest of the signal is blocked. However, if altitudes match the speed and heading of the two planes are compared to give a relative velocity vector. At the same time the direction finder is actuated to give a line-of-sight reading. Coincidence of the two means aural and visual warning and appropriate turning commands.

Sorting of signals is handled by gating circuits in the following sequence:

1. If altitudes match, a gating pulse allows the



Block diagram of transmission, detection, computation, and action taken by a cooperative collision avoidance system.

rest of the signal to pass to the computer and starts the direction finder.

2. The receiver is locked to prevent signals from a third or fourth aircraft from entering the circuit.

3. The receiver is opened at precisely the time the next signal is expected from the first airplane. This is possible as all planes transmit at the same repetition rate.

4. When a comparison is finished, an antiblanking signal opens the receiver again so information from other aircraft can be examined.

5. Finally, a disabling signal forces a constant tracking of any signal that shows a collision possibility until a corrective maneuver is made.

Partial Versus Full Cooperation

CAS can work if both planes transmit but only one has a computer to make a course correction. This combination might be found with a commercial airliner and a private plane. In this case the accuracy or performance of the system must be improved.

Two fully equipped planes can detect effectively at rates-of-climb of 2400 fpm and heading errors of 9 deg under expected operating conditions. If only one plane is turning the rate of permissible climb is divided by two, the heading error must be cut in half, and the detection distance must be multiplied by two. Even so, this would permit safe operations with less expense to the small or private plane operator. Military craft might use this solution because of space limitations.

Bonus Benefits

The CAS constantly transmitted information can be used for enroute flight control and terminal flight direction. In the first case the altitude, speed, and heading information is picked up by a ground-based fan-beam receiving antenna. Strategically placed listening stations could keep track of all flights over the continent. Terminal operations centers could have a fan-beam antenna that would be triggered by the CAS. The antenna position would give the bearing and the elapsed time between interrogation and reply will give the distance to the airplane. This, combined with the CAS transmitted information, would give complete flight information without the radio voice transmission now used.

Drag is minimized because a simple dipole antenna, imbedded in the dorsal stabilizing fin, is the only external component needed. The direction finder can be located in the pilot's cabin.

To Order Paper No. 438 . . .
. . . on which this article is based, turn to page 5.

Abridgment of an

SAE Metropolitan Section Paper

Airframe Managements Face Shrinking Markets and Tough Competition

Excerpts from paper by

Edward Stone

chief economist, The Martin Co.

TODAY, managements of airframe manufacturing companies are confronted with the serious problem of a shrinking market for their old reliable, the aircraft, and increasing outside competition for the rival which is displacing the aircraft to such a great extent.

Coupled with this is the problem of personnel—fewer production workers with lesser skills, and a change in the engineering talents required to carry on missile development and production. The aerodynamicist is giving way to the electronics engineer, and these are in short supply. The industry faces a considerable upheaval and one which cannot be taken by slow steps. Already, airframe manufacturers have felt the repercussions of the changed requirements of their customer, the Air Force, and the pressure of the competition provided by non-airframe manufacturers for the most important part, dollar-wise, of the missile.

For aircraft there were many types for special purposes and more and more money was spent for quantities of these. But the missile program, despite the recent hysteria, will not mean production runs of the same quantities (at least in money terms) as were common for aircraft, except in a few limited cases.

More Dollars for Missiles

As engineers, you know the aircraft market has been shrinking for some time and the missile market has been growing at its expense. Back in 1951 when the military was spending $2.4 billion on aircraft, only $21 million was being spent for missiles. By 1954, expenditures for aircraft had risen to $8.3 billion and the amount spent on missiles had increased from 0.9% of the total spent on aircraft and missiles to 5.7% and equalled $504 million. The fiscal 1957 figures show that out of a total of about $10 billion, $8.0 billion was spent for aircraft and $2.1 billion, or 20%, for missiles. The 1958 figures indicate that about $9.7 billion will be spent on those two items with missiles coming up to 26%, equal to $2.5 billion. It is anticipated that by 1960 equal sums of procurement money will be spent on missiles and on aircraft. By 1967, the missile business will be humming along to the tune of about $5.0 billion of Defense Department expenditures versus about $4.0 billion for aircraft. That's some change!

This means that a lot of facilities designed for and

The problems confronting airframe industry managements can be summed up as:

1. The accelerated obsolescence rate of aircraft.

2. The growing market for missiles at the expense, primarily, of aircraft.

3. The growing "outside" competition for the missile market via the electronics manufacturer, reflecting the increasing relative importance of electronics to the overall cost of the missile.

4. The excess capacity in airframe facilities which has developed.

5. The declining production runs for aircraft not fully compensated for, dollar-wise, by most missile production activity.

6. The declining market for aircraft engines not compensated for, dollar-wise, by missile engines and the new competition in this area also.

7. The changed technical requirements and the consequently different professional skills required with the problem of where to obtain the new skills and what to do with the displaced professional people as well as displaced highly-skilled production workers.

8. The cost consciousness of the general public and the mounting cost consciousness of the Defense Department leading to pressures for greater efficiency by the producer and changes in some of the ways in which aircraft manufacturers have traditionally carried on their activities.

9. The probability of Defense Department spending for aircraft and missiles not keeping pace with the increase in gross national product, which over the next 10 years will grow by 50%. Aircraft and missile spending would have to increase by $4.5 billion to keep up, and this is not likely. So, some companies will suffer at the expense of those which grow.

10. This poses then to management the immediate questions of how to protect the company and its stockholders; how to protect their employees; how to remain competitive; and how to foresee the new technology which will affect their future, also.

used for the production of aircraft will represent excess capacity. Indeed, there's plenty of that already. The aircraft industry cannot afford to delude itself with the thought that the Defense Department will pay for the maintenance of this excess capacity on a standby basis. It has already served notice that it won't do so.

But, in addition to excess facilities, the decline in aircraft production has meant excess manpower in the plant and even excess engineering manpower. Follow-on aircraft will be of fewer types, and the quantities produced will be much smaller. Fewer new aircraft development programs will be started, and the aircraft production runs will be smaller.

Aircraft manufacturers, confronted with mounting costs in the face of declining demands for aircraft, have had to slash payrolls. In the usual instance, they have been unable to transfer the excess aircraft technical and production workers to guided missile programs. This has been because, in many cases, they have not been prepared for missile work and, in others, where they have been fortunate enough to be thus forearmed, and actually have missile contracts, these are relatively small and could not absorb all of the displaced personnel even if it possessed the skills required.

Consequently, management today in this industry is confronted with excess manpower, excess facilities, and a knowledge that missile production, in most instances, will probably not be in the relatively large quantities on which management has based its aircraft production estimates and schedules.

Costlier Electronics, Less Airframe

During World War II, many companies entered the electronics field, producing such electronic equipment as computers, instruments, and fire control systems. Since World War II, other electronic companies have sprung into existence and have also been supplying the Defense Department with electronic products. Today, it is estimated that the electronic equipment in aircraft accounts for about 25% of the overall price of the plane and in the case of guided missiles, accounts for 30%; while, if the electro-mechanical equipment is added, it accounts for about 55% of the entire cost of the missile. In contrast, the frame for the missile accounts for only about 20%, whereas in the case of planes, it ac-

Airframe Managements Face Shrinking Markets and Tough Competition

continued

counts for about 70% of the procurement figure.

Also, it is estimated that the electronics portion will grow to about 40% and the electro-mechanical to 30% or a combined total of about 70% of the entire cost of the more complex missiles. The airframe will come out as second-best; its share will be 12½% of the total cost of the bird. Small wonder then that airframe manufacturers are looking seriously and anxiously into the possibility of theirselves producing the electronic systems and components required for the missiles.

So today the airframe manufacturers are not only confronted with a shrinking demand for their customary product, the airplane, but they find that their traditional activity of designing and producing airframes, when applied to guided missiles, will represent but a minor part of the missile from the standpoint of cost, reflecting the engineering and production work as well as material required. Further, they find that competition for this blossoming substitute for their old main product, the aircraft, is no longer confined to just themselves. "Outsiders" have crept in through the back door by providing electronic products and electronic systems. In many instances, the airframe manufacturers find that these outsiders are actually getting the lion's share of the present missile activity from the standpoint of the relationship of what they supply to the total cost of the missile.

Similarly, the traditional manufacturers of aircraft engines are confronted with shrinking markets. With missiles, the engine will represent a smaller proportion of the cost of the bird. Powerplant procurement will decline from the present $1.5 billion per year to about $1 billion per year, the estimates are. Here also, new competition can be anticipated.

Airframe companies which already are fortunately in the missile business also face problems. A serious one is that of seeing the major part of the missile market, as represented by the electronic and electro-mechanical fields, going to concerns "outside" of the traditional aircraft industry so that the aircraft industry is left with but a small part of what the missile business really represents in terms of activities, sales, profits, and opportunity to grow. Hence, these manufacturers must make a determination as to whether they shall branch out into the electronics area. This, of course, calls for a careful review of their abilities to develop the necessary skills within a practical time span, for the competition is keen and those who become entrenched within the next few years will have the business. It will be difficult to dislodge them because of the experience they will have gained and because of the good reputations they presumably will have earned.

The aircraft manufacturer not now in the missile business faces the question of how to get into it. If he doesn't, what's his alternative? That is, of course, if he is not currently successful in producing planes with his full capacity and getting additional orders for new planes. Here also, time is of the essence.

So, managements already in the missile business as well as those not in the missile business will be considering seriously whether they should not attempt to broaden their base of activities by utilizing their knowledge and their existing skills in the production of other defense items where these skills can be and are important. But, with time hounding them, managements might have to decide that there is just not enough time to build from "scratch" and thus they might be seeking companies already established in a given field, and by purchasing them, use them as the new foundation stone upon which to build.

Merge or Go It Alone?

With the growing competition already alluded to, management of some companies will have to make a serious decision as to whether it would be more advisable for them to seek a merger with a stronger company rather than to go it alone. A period of increasing, intensive competition brings about an "urge to merge" era. Some of this will doubtless be seen in this industry as managements seek to strengthen the position of their own stockholders and to assure continued employment for their skilled and loyal workers by assuring themselves of a share of the market.

Broadening the base of their defense activities through entering into the manufacture of defense products which they had not been heretofore producing, or merging with a company producing such different products, is one way of providing diversification—and an important one.

Managements also, however, will be mulling over the problem of whether they should remain solely in the business of producing for the Defense Department or whether they should broaden their base by diversifying into non-defense items, using again for this purpose the experience and training of their personnel. Some companies which are producing planes for both the military and commercial markets have this type of diversification, but this is all related to one particular product. Some managements which cannot adapt their military line for the commercial market, will be considering whether they should enter the commercial market through the production of other items.

Their skills and experience could be used for some non-defense goods even though they are entirely different from military hardware. In this case, careful consideration must be given to such factors as the differences in the markets and the consequent sales effort and distribution mechanism required, and above all, the fact that even more cost control is required to be successful in the commercial market than in the military market.

To Order Paper No. S49 . . .
. . . on which this article is based, turn to page 5.

Between sessions, engineers studied new products and services on view in Meeting's Aircraft Engineering Display.

Aeronautic Meeting Considers Missiles, Mach 3 Transports

THE SAE National Aeronautic Meeting, April 8–11 at the Hotel Commodore in New York, left no doubt that the Society is becoming well established in the new technologies of missiles, space vehicles, and supersonic transports.

Although registration was down 15% from the similar Meeting a year ago, preprint sales were up 30%. The papers that accounted for the increase were mainly those on boron fuels, the ion rocket engine, liquid versus solid propellants, and powerplants for supersonic transports. Even at $4 per plate, the luncheon at which C. L. "Kelly" Johnson, vice-president for engineering of Lockheed, spoke on "A Current View of the Status of the Supersonic Jet Transport" sold out.

Correspondingly, problems of producing missiles and other hypersonic aircraft cropped up often in the six Production Forum panels arranged by a committee under the leadership of Forum Sponsor Mundy I. Peale, president of Republic Aviation, and Kermit Wasmuth, Republic's director of quality control.

Programs for the 15 technical sessions were planned by a 54-man committee headed by General Chairman G. N. Cole, chief of engine design at Pratt & Whitney Aircraft.

Others responsible for arrangements for the Meeting included M. G. Beard, dinner-dance; W. Thomas Stark and Frank B. Lary, attendance promotion; Ivan Sherman, publicity; R. N. Durham, reception; and Charles Froesch, Aircraft Engineering Display.

During the Meeting, the SAE Council, the Planning for Progress Committee, several SAE technical committees, and the three aeronautic Activity Committees met.

V. I. Weihe (extreme right), who was chairman of the Air Traffic Control session, amuses session participants with a joke just before the session begins.

Part of panel on "Company-Wide Approach to Improvements in Productivity," one of six all-day Production Forum panels at the Meeting. At right, E. D. Gibson.

Kermit F. Wasmuth and Mundy I. Peale, Production Forum chairman and sponsor, respectively, tackling their corn flakes at Forum's kickoff breakfast.

Big engine in Aircraft Engineering Display and two of its intent viewers.

Malcolm A. MacIntyre, center, Undersecretary of the Air Force, spoke on "Procurement Trends" at the Tuesday luncheon. Afterwards he was interviewed by many of the 34 members of the daily and trade press who covered the Meeting for their publications.

Eugene Manganiello of NACA and Joseph Gilbert, assistant general manager of SAE, interrupt chat on Planning for Progress to pose.

Session Secretary Mario A. Pesando of Avro, Session Chairman William W. Thomas of Vertol, and speaker R. S. Ross of Goodyear Aircraft at Meeting's opening session on VTOL and STOL Developments. Ross described a proposed aircraft having a rotor for propulsion and hovering buried in its thick, louvered wing.

Ideas garnered at the Meeting's

Aeronautic Production Forum

Tuesday and Wednesday, April 8 and 9

IMPROVED quality control appears to hinge on better use of accumulated "defect" data. An answer is being sought in the effective application of data processing equipment.

Another approach to better quality control is the current trend to placing the quality control representative on the company "team." This is expected to aid in the timely, economical delivery of an acceptable product. The team approach, in itself, is gaining wide acceptance as an improved method of securing economical introduction of new products into manufacture.

Some companies now require that quality control costs be charged against a specific order or program. This includes the costs for such items as labor, supervision, gages, and handling equipment.

MANAGEMENT must have the ability to determine whether to "make" or "buy." The decision to make a new part or product often involves a large initial investment since material and equipment must be purchased, storage space provided, and additional labor supplied.

When a company decides to buy they take advantage of the research and development experience accumulated by a vendor over a number of years. This is often a costly and time-consuming process. If management decides to make the product research and development costs have to be incorporated into the budget.

NEW development programs must be organized from the outset under single leadership for a coordinated effort which allows effecting the compromises necessary to productize a research and development effort within a reasonable time and within practical dollar limitations. The success of the program will depend on the degree of coordination between engineering, manufacturing, and quality control.

BAD ATTITUDES use up energy that could be devoted to production. To improve productivity, therefore, a climate must be created in the plant which is conducive to good attitudes.

Accident rates, grievances, absence rates, turnover, and the like will give some indication of the attitudes existing in the plant. Where possible, management should keep close to employees to notice what attitudes exist.

The main objective, however, is to continually improve attitudes and thereby increase production. Aids to this end include:

1. Making sure the employee feels he is doing a needed job.
2. Making sure he understands the operations associated with the job.
3. Showing him that his work ties in with the work of others.
4. Making sure the job carries self-respect.
5. Making sure the work offers some challenge to the man's abilities.

NUMERICAL control appears to be most adaptable to fabrication machines used for short research and development type runs demanding high versatility and accuracy.

As an example of accuracy of numerical control, consider a certain aircraft part which weighs 900 lb. Because of material and fabrication tolerances there was an observed variation of up to 90 lb on the part using conventional manufacturing processes. By using numerically controlled machines, it was possible to keep maximum weight variation to about 10 lb. Many companies are incorporating additional information on engineering drawings to permit fabrication with numerically controlled machines. An MIT study suggests eventual elimination of drawings with replacement by reference process tapes and perhaps a rough sketch for use with numerically controlled machines.

HIGH COST of new machines and the long delivery times associated with these machines is leading to greater improvisation of present plant equipment.

In one job shop only 10% of original equipment is in the "as bought" condition. The other 90% has been changed in every possible manner so as to be adaptable to specific jobs. Often, a little more elaborate tooling eliminates the need for a new machine.

Where time is not a problem, new machines may provide a definite economic advantage. Whether this will be so or not has to be determined by economic studies of old versus new machines. One company representative revealed that a machine they bought for $70,000 will pay for itself in about 5 months.

MISSILE EXPENDITURES will rise to $2.8 billion in 1961 while procurement of manned aircraft will decline to less than $2 billion in the same period, said Malcolm A. MacIntyre, Undersecretary of the Air Force.

"Industries now considered as secondary sources of airpower hardware may become the primary manufacturers. In other words, industries now specializing in electronics and propulsion may become our prime contractors."

MacIntyre advocated devoting considerable effort to the development of vastly improved propulsion systems and says that "interesting possibilities are ion, photon, fission, fusion, and solar energy sources." The future will be "an era of severe transition" where it will be necessary for industry and the Air Force, working together to move in three avenues at once.

"First, we must maintain our current high level of deterrent airpower. Second, we must compress the design-to-inventory cycle of hardware production so that our deterrent capability can be successfully projected into the immediate future. Third, we must exert maximum energy to penetrate the barriers to long-range space operations."

Secretaries' reports of these panels will be available in full in multilith form as SP-323.

Capsule reports of all 15 technical sessions and 2 luncheons

Tuesday

VTOL and STOL

—Fully shrouded rotors and boundary-layer control are two ways of achieving short landing distance while maintaining high-speed performance.

A lightly loaded, large rotor proves to be near helicopter efficiency in hovering. Changing the airflow direction rather than rotating the engine or aircraft is a configuration proposed for a buried rotor convertiplane. (Paper 37A)

At the other extreme, Mach 1 plus jets can use engine-blown boundary-layer control to cut take-off distances up to 25%. (Paper 37B)

Helicopter engineers continue to push forward on maintenance and operating problems. Improved design, personnel training, parts distribution, facility organization, and service tools are keys to improvement. (Paper 37C)

Jet Transport Piloting

—If air traffic control permits, the optimum range can be achieved by flying a cruise-climb flight path. The pilot should stabilize at a constant Mach number and allow the aircraft to climb slowly as the weight decreases. (Papers 38A and 38B)

With a new take-off indicator, as the plane moves down the runway, the pilot need only observe the relative positions of the take-off marker and the indicated airspeed pointer. So long as the indicated airspeed pointer is ahead of the take-off marker, all is well. If the take-off marker at any time during the run catches up to the airspeed pointer, the take-off should be aborted. (Paper 38C)

Very-High-Speed Flight

—The reduction in stagnation temperature beginning at speeds of 7000 fps due to dissociation tends to be offset by the effective increase in specific heat combined with its influence on Prandtl number. Therefore aerodynamic heating rates occurring on a body flying at these speeds are about as high as those calculated using the undissociated stagnation temperature. (Paper 39A)

At great altitudes cabin pressurization becomes very difficult both because of power required and because of the air temperatures. At 70,000 ft compressor exit temperature would be 700 F. The sealed cabin seems the only answer. (Paper 39B)

In a gas at elevated temperatures, such as occur behind the bow shock of a high hypersonic missile, there is a coupling between the electrical properties of the fluid and its mechanics. "Magnetohydrodynamics" deals with the resulting equations for the magnetic, electric, and velocity fields. (Paper 39C)

Navigational Instruments

—Simple, lightweight Doppler systems are available for providing continuous ground speed components to the navigation computer. (Paper 40A)

In new integrated Air Force flight instruments, all navigation information is centered horizontally in a tablelike manner before the pilot. It's as if he were looking downward at the terrain through an opening in the table top, viewing his own plane from above. (Paper 40B)

In the near future, windshields can be replaced by an orientation display on a cathode ray tube. The Army-Navy Instrumentation Program has developed such a tube, and it is being flight tested. (Paper 40C)

Wednesday

New Sources of Propulsion Energy—

Boron-carbon-hydrogen fuels may make possible missions that couldn't be accomplished with other fuels. But the boron fuels are costly — perhaps $0.65 to $1.00 per lb instead of the $0.04 per lb for hydrocarbons. (Paper 41A)

Boron hydrides will be more difficult to use than hydrocarbon fuels because of toxicity, thermal decomposition, flammability, and sensitivity to water. Their high flame speeds and wide flammability limits should aid combustion in engines, however. (Paper 41B)

It might be possible to keep a very light ramjet orbiting indefinitely at an altitude of 60 miles or more, using the atomic oxygen existing naturally there as a result of the sun's ultraviolet radiation. The ramjet would recombine the atomic oxygen into molecules, releasing its energy and heating the gas stream. The increased pressure and velocity of the gas issuing from the rear of the duct would thrust it forward. Recombination might be accomplished catalytically or by compression. (Paper 41C)

An ion rocket engine in which the propelling ions are accelerated by an electrostatic field would have the capability of producing usable thrust levels and might supplement chemical and nuclear rocket engines for space vehicles. Major problems in the development of the ion rocket engine will be the ion thrust chamber, the propellants, and design of a high specific power generator. (Paper 41D)

Supersonic Transports

—Giving "A Current View of the Status of the Supersonic Jet Transport," C. L. Johnson proposed a Mach 3 airliner that would fly coast to coast in an hour and 20 minutes — or from New York to Paris in two hours. "There's no sense in being a little bit supersonic. Let's go!" he urged.

His proposed airliner would use an afterburner for an extra burst of power at altitudes above 50,000 ft to accelerate up to cruising speed. But to avoid noise over cities, it would not use the afterburner for take-off and climb.

The Mach 3 transport will be long and sharp and weigh about 450,000 lb. It will fly as high as 80,000 ft, but its wing loading will be only 40–50 lb per sq ft. Range will be 3500 miles at 2000 mph. If the airlines could afford the plane, and the political situation warranted, the Mach 3 airliner could go into service in 1965 or 1966.

Advanced Powerplants

—Development of a casting process for solid propellants now makes it possible to construct large solid rocket engines. Over the next 10 or 12 years, it looks as if solid rockets may be used for IRBM's, ICBM's, ICGM's, air-to-air and air-to-ground rocket weapons, and vernier rockets for space flight. Liquid-propellant rockets will excel in specialized missile applications requiring high performance or extremely large sizes, satellite propulsion systems, and space flight systems. (Paper 42A)

Turbojets for supersonic transports will require turbine inlet temperatures of 2000–2200 F for take-off. Design compressor ratios will be in the vicinity of 8 to 12, with the lower values being more desirable at the higher flight speeds. The higher jet velocities and the greater airflow will boost noise levels. (Paper 42B)

Papers on which these capsules are based are available in full

at the SAE National Aeronautic Meeting, April 8-11

Thursday

Air Traffic Control — In a new Navy carrier-landing system, air traffic control is provided for as many as 100 aircraft at ranges up to 200 miles and at altitudes up to 80,000 ft. The planes are controlled to a gate 8 miles aft of the carrier and at an altitude of about 500 ft. At the gate, each aircraft is assigned to a moving block of airspace. These blocks move toward the carrier single file as on an endless conveyor belt. In case of a wave-off, the plane returns to a point where it can be fitted in for a second try. Once the plane is in the precision landing phase, it is controlled automatically to the carrier deck. (Paper 43A)

A cooperative collision-avoidance system has been developed having sufficient detection range to prevent the collision of two piloted aircraft operating at any conceivably possible speed. (Paper 43B)

Missile Manufacturing — Assembly line techniques are being developed to increase the output and reduce the cost of missiles.

Techniques of economical mass production and developmental manufacturing are being combined. Because of the speed of progress being made, however, it is not yet possible to use automated production methods.

By organizing teams of personnel from engineering, tooling, manufacturing, and quality control departments, it is possible to break a missile down into its components — structure and electronics — and so to expedite production. (Papers 44A, 44B, 44C, and 44D)

SAE and Missiles — SAE's standardization efforts have led not only to reduced costs and complexity, but to improved reliability of our weapons, said William M. Holaday, Director of Guided Missiles, Department of Defense. "I am particularly pleased to see the SAE broaden its scope of activity to include missiles engineering," he concluded. "Its technical meetings and committee work may have even more significance here than in the aeronautic and automotive fields. SAE's work has always been good . . . and I wish SAE engineers increasing success in the future."

Current Engines — The TJ38 commercial jet engine uses a relatively low turbine inlet temperature. It is 1340 F for 12,500 lb thrust on a standard day at a specific fuel consumption of 0.718 lb hr-lb. At normal cruise, temperature is 1050 F, thrust is 3000 lb, and sfc is 0.880 lb per hr-lb. (Paper 45A)

Performance of a turbine engine deteriorates as dirt accumulates on compressor blading. When power of the Model 501 turboprop drops 5% below specfiication, Allison recommends that the compressor be cleaned by injecting ground walnut hulls into the engine inlet. (Paper 45B)

A magnetic-drum-type computer provides the processing paperwork and maintains perpetual status records for GE's entire turbojet spare parts activity. (Paper 45C)

Materials for High Speeds — Needed immediately are materials which can withstand aircraft and missile outer skin temperatures approximating 2000 F for one to 100 hr. Ceramics, necessary for electronic applications at elevated temperatures, have many desirable mechanical and thermal properties.

No one ceramic coating possesses all the desirable properties however. Each application must be carefully studied and evaluated in the design stage to select the most effective ceramic. (Papers 46A, 46B, and 46C)

Friday

Turbine Fuels and Lubricants — Besides the conventional properties, turbine engines require control of two more: (1) thermal stability, which characterizes the fuel's ability to undergo high temperatures without forming deposits, and (2) burning characteristics, which relate to the fuel's ability to release its energy in a way that will not abuse surrounding engine parts. (Paper 47A)

For lubricants, the Air Force foresees service temperatures of 800 F for bearings, 600 F for gears, hot spots at 1000 F, bulk oil temperatures of 600 F. (Paper 47B)

Missile Engines and Systems — The turbine engine is the logical powerplant for the cruise missile. It results in a lowest gross weight and smallest size. (Paper 48A)

As missiles become more complex, so does checkout equipment. A new guidance system may require checkout equipment as complex as the guidance system itself. (Paper 48B)

On some missile complexes, ground equipment is more than half of the weapon cost. Test stands, maintenance and checkout equipment, and launchers must be as reliable as the missiles themselves. (Paper 48C)

The flywheel is the lightest source of auxiliary power for missiles where power is needed for only 1-2 min. The reciprocating engine is lightest for all longer durations. Monopropellant turbines and silver-zinc cells are generally competitive on weight. The cells seem worth further study, especially for durations of 2-5 min. (Paper 48D)

Powerplant Control Systems — Selection of the optimum mode for controlling an aircraft engine requires investigation of the operation of the engine and weapons system at every stage of its use. The analog computer is a most useful tool for the job. (Paper 49A)

At Mach 2 the compression ratio of the induction system is about equal to the compression ratio of an axial compressor in a typical high-compression turbojet engine. That's why design of the variable-geometry inlet is so vital. (Paper 49B)

Jet thrust reversers can be simple and reliable if they are cut loose from propeller reversing practice. In-flight control and modulated response are two main features that can be added to the landing-run braking function. Independent reverser control is the big difference between propeller and in-flight jet thrust reversing. (Paper 49C)

Airlines Engineering — A computer could be very useful in laying out flight schedules. It could take detailed account of existing traffic and future estimates, cost of moving crew members to other bases, costs of retraining crews to fly new aircraft, and other factors too troublesome to include in hand calculations — as well as the factors usually considered. (Papers 50A and 50B)

Small errors in instruments can make a big difference to jet transports. For example, an increase of 1 C can reduce the permissible take-off weight by 0.5%. Therefore, a weight penalty of 700 lb can result from a 1 C error in the outside air temperature reading to be used for take-off. Alternatively, take-off distance would be increased 150 ft by a 1 C increase. (Paper 50C)

in multilith form from SAE headquarters. See order blank on page 5.

C. L. "Kelly" Johnson of Lockheed beginning his talk on "A Current View of the Status of the Supersonic Jet Transport" at the Wednesday luncheon.

W. K. Creson, SAE president, and G. N. Cole, general chairman of the Meeting.

Activity Committee Chairmen and Vice-Chairmen George Haldeman, J. D. Redding, Harrison Holzapfel, R. H. Loughran, and C. E. Mines conferring at breakfast on joint interests of the Aircraft, Aircraft Powerplant, and Air Transport Activities. Air Transport Activity Chairman Carl Christenson (at right) came to New York but was called away before the Meeting began.

C. F. Newberry, R. W. Young, and R. E. Matzdorff. Newberry and Matzdorff, both of Marquardt, received the Manly Memorial Award for their paper on inlet control systems. Young presented the medals, scrolls, and checks.

Aircraft Engineering Display occupying Commodore's main ballroom was the scene of many earnest technical conversations — and an occasional playful toss of the saucer-like plastic "frisbees" available from one booth.

M. G. "Dan" Beard, chairman of the Sky Ball dinner-dance that brought the Meeting to a gala close on Friday evening and eight of the airline stewardesses who distributed boutonnieres and corsages to the guests. Many of the flowers were flown from overseas.

Luncheon speaker William Holaday, Director of Guided Missiles, Department of Defense, with Arthur Nutt.

Dr. C. E. Barbour, Sr.; James Martin accepting the Laura Taber Barbour Award honoring him for developing ejection seats; Frazar B. Wilde, Award chairman; Admiral J. H. Cassady of Flight Safety Foundation, which administers the Award.

At Wings Club: Hugh Harvey, R. H. Boden, Leslie Neville, Frank Klein, R. J. Heaston (hidden), and Mrs. Heaston. Neville and Mrs Heaston got preview of session on New Sources of Energy for Propulsion, in which other guests participated next morning. Neville was on his way to a dinner for F.A.I. delegates.

John Lowry of NACA Langley Lab, member of Air Transport Activity Committee, summarizing for Committeemen their replies to a questionnaire on supersonic transports of 1975.

IMAGINEERING luncheon spokesman J. R. Ballinger, Emerson Welles, and Ralph Cross (left to right) submit to applause rating as judges check applause meter for audience reaction.

Imagineering Luncheon Highlight of Meeting

How do you tell the boss he's wrong?

If you had attended the "Surprise" Luncheon on April Fool's Day, sponsored by the SAE Production Activity at Chicago, you'd now know a dozen different ways to tell the boss he's wrong.

A new idea for member participation at SAE luncheon meetings, this brainchild of Anderson Ashburn, meetings vice-chairman for SAE Production Activity and J. E. Adams, vice-president, SAE Production Activity, was undoubtedly the high point of the recent 3-day 1958 National Production meeting. No details of the luncheon program were given out prior to the meeting.

SAE members and guests attending the luncheon became either "Squares," "Rounds," or "Rectangles" — and sat at tables of the same shape. Before being served, they were asked to look under their plates. A blue ribbon under his plate meant that member was chairman for his table. An accompanying card assigned each table a subject for discussion. Three subjects were used at Chicago: What Can We Do to Improve Employee Productivity? How Can Committee Action Be Effective? How Do You Tell the Boss He Is Wrong?

At each table the subject assigned was discussed during the luncheon period. All those seated at the table participated in the discussion. Following the general discussion, a spokesman for the table was chosen and the ideas contributed by the group were summarized. Spokesman for the "Squares," "Rounds," and "Rectangles" then competed in each classification with 2-min talks on the assigned subjects. Winners of the contest were the Squares. Ralph W. Cross, executive vice-president, The Cross Co., as spokesman for the Squares, won the top winner award, a new electric toaster.

The winner was chosen on the basis of readings on an applause meter. A novel touch was the use of a real toastmaker by the toastmaster, Andy Ashburn. Fresh bread went into the toaster when a spokesman commenced to talk. When the bread popped out, both the toast and the speaker were done!

Production Stresses

BETTER Products at Lower Cost provided the theme for the 1958 SAE Production Forum, March 31–April 2, at Chicago.

Eight lively morning panel sessions covered subjects ranging from new techniques in heat-treatment to the vital question, Where do we go from here with numerical controls?

Prepared technical papers were presented at two afternoon sessions. The third day was reserved for plant tours to Ford Motor Co.'s Aircraft Engineering Division and the Mfg. Research Department of International Harvester Co.

Changeover — One Automation Problem

Many interesting engineering developments were discussed by the various production panels participating in the Production Forum. For example, at the panel discussion, "Automation in Assembly," it was pointed out that, while the "building block" machine tool concept has helped in promoting flexibility in automatic transfer machines, there is still a lot of electrical "debugging" required when attempts are made to change transfer lines over to a new product. Some companies, it was reported, are using plug-in type electrical components instead of conventional electrical gear to minimize lost production time during a changeover. It was also emphasized that the more farsighted the planning going into automatic equipment, the easier will be the changeover — if it comes.

One point stressed at Chicago was the importance of setting up special groups which are given specific assignments to study automation possibilities. Integration of these groups into engineering and manufacturing is an important consideration.

Another problem discussed was the question of evaluating and costing automation setups. Complex accounting is involved in almost any case, it was pointed out. Many intangibles have to be considered. The problem of allocating burden offers no simple solution.

Coordination Needed Between Engineering and Manufacturing

Particularly in times like these, it was emphasized, close coordination be-

Meeting Cost Reduction

tween engineering and manufacturing is essential. Some degree of cooperation exists in all plants, it was pointed out, and no two situations or systems are identical.

At the Chicago meeting, case examples were presented to show how effective cooperation between engineering and manufacturing can be achieved. A prominent producer of industrial equipment set up a special committee for the purpose. Sales, engineering, manufacturing, standards, personnel, and cost departments are represented on this committee. Final consideration is assigned to a smaller committee in which primarily engineering, purchasing, and methods departments participate. To mention an example, this kind of cooperation produced a reduction in weight of 25% and a cost saving of 30% on a particular assembly, it was reported.

An engine manufacturer told how research, engineering, and operations departments, as well as quality control and purchasing, cooperate in new product planning and development. There is direct consultation between engineering and manufacturing for the purpose of facilitating manufacture. In this company, production engineering serves as a liaison between manufacturing and engineering and also handles day-to-day production problems, including specifications, tolerances, assembly techniques, and tooling.

Another prominent manufacturer holds regular monthly meetings attended by engineering and manufacturing department heads. In this way, manufacturing personnel serve as a consultant to engineering, and engineering serves manufacturing in a similar capacity. In this setup there are also a staff estimating group and various cost analysts.

A large truck producer told how the production engineering staff serves as a liaison between engineering and manufacturing. In this instance, production engineering reports to engineering rather than to manufacturing. Cost estimators assist engineers with preliminary cost studies. A program planning group sets up the testing program, plans releases, and the like. Production engineering takes over in the final pilot stages of a new product program and later turns the program over to manufacturing.

Communications Is Key to Cost Control

The essence of sound cost control is good communications, SAE members were told at Chicago. The importance of separating major areas — direct labor, indirect labor, supplies, and tooling — was underlined. Advice given was: use a team approach, if possible, and make sure all members of the organization, including foremen, are informed about budget problems.

A strong plea was made for studying equipment at hand thoroughly for cost savings opportunities before purchasing new facilities.

An interesting point brought out with respect to maintenance programs was the observation that if more than 20% of your maintenance budget is being spent for unanticipated repairs, you are probably not spending enough for preventive maintenance.

Another suggestion advanved at this session was made in repsonse to the always present program of longer hours versus an additional work shift. A panel member reported that an investigation by his company showed that productivity of the third shift was only 40% as high as first shift productivity. There are contributing causes, of course — inferior workers, more interruptions, and such. The problem would have to be decided, it was suggested, not only on the basis of productivity and quality of the work; community practice would also be a factor for consideration.

Carburizing Furnace Draws Praise

At the heat-treatment session the conspicuous virtue of the batch-type carburizing furnace — outstanding versatility — drew warm praise. Consequently, equipment of this type fits the need for equipment that can be adjusted for rapid changes in volume.

High-temperature (1900 F) carburizing came up again this year for considerable discussion. While there may be penalties with respect to grain growth and possible grain boundary precipitation, the rapid production rate — about double the 1700 F rate — makes this approach to carburizing intriguing. Of course, temperature and time cycles must be closely controlled, it was pointed out.

Another interesting report dealt with experimental use of a water quench medium to which 0.20% poly-vinyl alcohol had been added. Cooling rate of this solution is between oil and water. This quench is being used commercially although it must still be considered to be in the experimental category.

Computers and Numerical Control Arouse Interest

Two up-to-date engineering subjects — computers and numerical controls — drew considerable comment at the Meeting.

Computers are being used today for a wide diversity of applications. These include designing hole spacing for heat exchangers as well as pressure vessel components, air conditioning systems, electric motors, and truck frames. Each of these applications may be found in a single large-mid-western company.

Other jobs being performed successfully by computers today include: 1. labor efficiency control where savings up to $50,000 per year were reported by one firm, 2. production scheduling, 3. machine scheduling, 4. deciding what, when, where, and how much to buy, 5. bills of material reports, 6. stock reports, 7. shop schedules, 8. production and sales forecasts.

One company reported its computer reports show the position of each product now and for 9 months in advance. There can be little doubt about it: computers are finding many and varied jobs in U.S. industry.

What's coming up next in numerical controls for machines? Here are some suggested applications: 1. positioning systems for drilling holes for condenser plates, 2. positioning systems requiring high accuracy, as for boring machines, 3. completely automatic turret lathes, 4. new contouring systems.

Comparing numerically controlled setups with conventional methods, it was pointed out, the data processing equipment is new. Tooling and fixture design for a given application may be cheaper using numerical control. These elements are common to both systems: manufacturing equipment and supporting equipment. Other factors that must be considered include personnel training, inventories (these may be lower with numerical control), total capital cost, production planning and scheduling, floor space requirements. Not until all of these factors have been studied will it be possible to compare accurately the cost of conventional versus numerical control manufacturing setups, it was argued.

A number of numerically controlled machines operating today are very complex, high cost installations. Most

LAST-MINUTE ARRANGEMENTS for Imagineering Luncheon are checked by Anderson Ashburn (left), meetings vice-chairman for SAE Production Activity and J. E. Adams, vice-president for SAE Production Activity. Ashburn was toastmaster at the luncheon.

DISCUSSING contents of Meetings program are: (left to right) J. T. Greenlee, Imperial Brass Mfg. Co.; SAE President William K. Creson; R. C. Ingersoll, president and chairman of the board, Borg-Warner Corp., J. A. MacLean, Bendix Aviation Corp., and general chairman of the Meeting. Ingersoll, guest speaker at one of the luncheons, spoke on "Engineering: The Key to Industrial Growth." MacLean welcomed members and guests to the luncheon and Greenlee was toastmaster at the luncheon.

PRODUCTION FORUM CO-CHAIRMEN J. D. Graham, International Harvester Co. (left) and E. O. Wirth, Bendix Aviation Corp. (right).

are operating in the aircraft industry. Machines of the future may be much simpler, it was suggested.

In response to questions from the floor it was pointed out that the transition from tracer-type operation to numerical control will be simplified where existing equipment can be used. Training program required for machine operators is very short but a week or 10 days training period may be necessary for maintenance crews.

Aircraft experience with numerically controlled machines has been favorable, with downtime ranging from 3% to 14%.

The outlook for numerically controlled machines is that they may find their optimum use outside the aircraft industry for runs ranging from 4 to 4000 parts. The key word to numerical control is flexibility. This is one reason why automotive applications are receiving such serious consideration today.

The final subject considered by the Forum was "Quality Control." Discussers emphasized the fact it is imperative for management to state clearly the objectives it hopes to reach through a quality control system. It was also brought out that specific answers can be offered only for a specific problem.

Roy C. Ingersoll, president and chairman of the board, Borg-Warner Corp., spoke at one of the two luncheons on "Engineering: The Key to Industrial Growth." In his remarks, Ingersoll paid high tribute to the contributions of our engineers in making possible the unparalleled expansion and development of this country. He predicted an even more important role for engineers in the years ahead.

General chairman of the meeting was J. A. MacLean, Bendix Aviation Corp. E. O. Wirth, Bendix Products Division, and J. D. Graham, International Harvester Co., were responsible for the selection of subjects and other arrangements for the 1958 Production Forum. William B. Shimer, DeSoto Division, Chrysler Corp., supervised presentations for the technical sessions. Cooperating with the SAE Production Activity was the Chicago Section of SAE, R. L. Smirl, chairman, and the SAE Engineering Materials Activity, E. S. Rowland, chairman.

Detailed reports by the secretary for each panel at the Chicago meeting will be published as a package in the near future by SAE. Members are urged to order these as soon as possible from SAE headquarters if they have not already done so. (Ask for SP-322. Price: $1.50 to SAE members. $3.00 to nonmembers.)

A total of four technical sessions, comprising 9 papers, was presented at the Chicago meeting. These papers have been preprinted and are now available to members at 50¢ each and nonmembers at 75¢ each from SAE headquarters.

SAE CEP COOPERATIVE ENGINEERING PROGRAM NEWS

New 1000-Rpm Power Take-Off Spec —A Boon to the Tractor Industry

MAKERS of farm tractors can step up power output substantially through use of SAE's new 1000-rpm power take-off standard. Use of the standard also permits interchangeability between existing 540-rpm and any new 1000-rpm machinery or equipment.

The 1000-rpm PTO standard, which will appear in the 1958-1959 SAE Handbook, offers the following advantages:

- Power transmission is increased by use of a small power shaft.
- Smaller universal joints and power-line drive cut the cost of implements having shaft speeds above 540 rpm.
- Faster PTO drive requires less speed reduction.
- Involute splines increases torsional strength.
- Telescoping of the power line between the two forward universal joints is possible since the horizontal distance from the power shaft to the drawbar hitch point is increased by two in.
- Alignment of power line, especially with hitch-mounted implements, is improved because (1) the vertical distance from the top of the drawbar to PTO is reduced from 6-15 in. to 6-12 in. and (2) the maximum offset of PTO from the tractor centerline is reduced to one in.
- More space is created for hitch-mounted implements by shortening the power shaft one in., increasing the horizontal distance from the drawbar hitch point by two in., and reducing the minimum tire clearance one in. This permits master shields to be reduced and moved forward.
- Safety is increased by improved power shaft shielding.

Tractor makers will face two problems as the new standard takes hold. They will have to expand their engineering programs during the change-over period. A swing to the new standard would also mean an increase in the production cost of implements having shaft speeds of 540 rpm or less.

Recent test results showed that:

(1) The torque transmitted by a tumbling shaft is reduced in direct proportion to the increase in operating speed.

(2) Performance of an implement at the cutter head or the hammer mill head is not affected by the speed of the tumbling shaft.

The new standard has also been accepted by the American Society of Agricultural Engineers.

A-16 Helps Air Force Whip Fuel System Problems

THREE members of SAE Aircraft Committee A-16, Fuel and Oil Systems and Equipment, helped solve fuel system design problems recently discussed by a joint Air Force-Industry Technical group at Wright Air Development Center. The Conference was called by the Air Force in an effort to overcome plumbing coupling problems encountered in some of today's military aircraft.

A-16 Chairman **P. H. Jones**, who heads the fuel system design section at North American, and committee members **K. R. Bragg** of Northrop and **F. S. Pepersack** of Martin gave technical assistance in guiding conference discussions.

Problems were attacked in three phases: The immediate emergency correction on current aircraft; a permanent solution; and a long-range program designed to avoid recurrence of the problem in future aircraft.

The latter resulted in the recommendation that thought be given to making A-16, or a panel thereof, the future advisory group to the Air Force on fuel system technical matters.

Conference discussions focused on fuel system leakage and other serious failures caused by aircraft vibration, thermal expansion, characteristics of synthetic seal materials, and complex maintenance procedures.

Property Specs for Metal Abrasives Proposed

THE establishment of SAE specifications for the chemical and physical properties of metal abrasives used for shot peening and blast cleaning was proposed at the first meeting of an ISTC Division 20 Subcommittee on Chemical and Physical Properties of Shot.

The need for such specifications was indicated by several subcommittee members who based their proposal on the thinking which follows:

- Uniform shot specifications would help clarify problems which appear to stem from the nature of the shot or grit being used, but which actually may be due to other causes.
- Many users have already developed their own shot specifications.
- Effective operation of shot testers requires accurate chemical and physical property information.

Subcommittee Chairman H. F. Kulas, Cleveland Metal Abrasive Co., has scheduled the next meeting during the Annual Shot Peening Conference which will be sponsored by ISTC Division 20 on May 5-7 in Colorado Springs, Colo.

New Countersink Spec Protects ½-1 In. Bolts

DIMENSIONS of countersinks for ½-1 in. bolts comprise the new SAE Standard on Countersinks for Cutting Edges and End Bits. The report will

Continued on next page

New SAE Committee on Ground Support Gear Will Aid Space Race

AS the race into space continues, a new SAE Committee on Aircraft and Missile Support Equipment (S-13) is standardizing support gear for missiles and jet engines. In this way, S-13 members will increase reliability and promote the exchange of technical data between designers and users of support equipment.

The importance of coordination between government and industry was stressed by William Holaday, director of the Guided Missile Program for the Department of Defense, at a recent Aeronautics Committee meeting in New York. In addition, Mr. Holaday said that for every dollar spent on missiles, two are spent on what it takes to transport, arm, fuel, test, launch, and track a missile.

Complexity of support equipment ranges from the simple jack to the intricate devices needed to cool systems during the countdown. Since SAE is the *only* technical society which has developed standards for ground vehicles *and* aircraft, it is the most logical place to initiate work which overlaps both areas.

Committee S-13 began work on a much needed catalog of existing equipment specification requirements at its second meeting held in February at the Naval Air Station in Norfolk, Va. Simultaneously, it is considering problems which deal with ground contamination of aviation fuels.

To insure competent technical handling of specialized problems, S-13 members will draw on the experience of various existing SAE aircraft committees: For example, the Hydraulic and Pneumatic Equipment Committee (A-6), the Air Conditioning Equipment Committee (A-9), or the Fuel and Oil Systems and Equipment Committee (A-16).

At the Norfolk meeting, which was led by Vice-Chairman R. G. Lohmann, six points were made in a discussion which followed an inspection of support equipment for several first-line jet aircraft.

(1) Manufacturers should adapt to existing equipment *before* designing new equipment.

(2) Parallel-rail-type equipment for engine handling is being well received.

(3) Equipment to check wheel and tire balance is needed.

(4) Maneuverability is a must, especially on shipboard.

(5) Pneumatic tires are considered undesirable and unnecessary on support gear.

(6) Many flights are aborted due to the failure of support equipment.

S-13 members also visited the USS Ranger at the Portsmouth, Va., Naval Shipyard. An extensive tour was made of a display of support equipment on the hangar and flight decks.

S-13 Vice Chairman R. G. Lohmann (l.), Martin Co., and Committee Secretary R. M. McClure (r.), North American Aviation, are shown support equipment by Com. J. A. Laurich, U.S. Navy Bureau of Aeronautics, at the Naval Air Station in Norfolk, Va.

Countersink Spec — continued

appear in the 1958–1959 SAE Handbook.

Maximum bolt head and minimum countersink dimensions were established to protect recessed bolts within the specified range. The new report also limits the physical dimensions of the square punched hole which will indicate when manufacturers should replace square punchers.

In addition, provisions are made to keep the square portion of the bolt head from turning when torque is applied to the nut during assembly.

Prepared by the Cutting Edges Subcommittee of the Construction and Industrial Machinery Technical Committee, the new standard is compatible with the ASA Standard on Commercial Plow Bolts.

Varnish and Sludge Related to Stop-and-Go

A PROGRESS report on varnish and sludge deposits encountered in stop-and-go driving is available as CRC Report No. 315. It reflects the work of 24 laboratories which conducted over 300 engine cycling tests producing deposits similar to those found in light-duty field service.

New Deposit Rating System

One concrete result was the development of a deposit rating system which is expected to improve reproducibility of results between laboratories. The CRC Engine Varnish and Sludge Group that directed the study, found that operating conditions, mechanical variables, engine type, fuels and lubricants all have a definite influence on the type and amount of deposits formed.

Among the mechanical factors studied, piston ring modifications were found to be influential. Tests showed that one piston ring design produced a consistently high rate of blowby, thereby accelerating deposit formations in laboratory testing. Operating conditions which resulted in deposits similar to those encountered in the field consisted of cycling operations involving idling, low-temperature moderate-load conditions, and higher temperature moderate-load conditions.

This cyclic operation will separate lubricating oils, engines, and fuels in regard to their influence on the formation of varnish and sludge deposits. Cover sludge, piston varnish, and oil ring plugged can be individually and variously affected by different oils.

Limited data suggest that the laboratory results could probably be improved with respect to oil ring plugging by increasing test duration.

To Order CRC Report No. 315 . . on which this article is based, see p. 5.

New Aero Lighting Group To Set Performance Goals

OPTIMUM performance standards for interior and exterior aircraft lighting will be set up by the new SAE Aircraft Lighting Committee (S-14). At its first meeting held in New York last month, S-14 outlined a plan to supplement the work of the Illuminating Engineering Society, which is primarily concerned with establishing lighting parameters rather than actual operational requirements.

Industry Guidance Needed

A need for industry guidance clearly exists, according to S-14 Chairman C. M. Christenson, director of Flight Safety, United Airlines. Mr. Christenson recently noted that 18 industry committees have been formed during the last 12 years, *but no single group has assumed the leadership necessary to establish widely recognized aircraft lighting standards.*

Comprehensive Report Planned

To accomplish this, S-14 is planning an all-inclusive report which will include standards prepared by SAE or other organizations. The current trend toward equipment interchangeability and increased flight speeds has created problems which point the way to such a document.

To implement the report, a steering committee and three subcommittees have been established. The subgroups are the Flight Deck Subcommittee (S-14A), Exterior Subcommittee (S-14B), and the Interior (Aft of Flight Deck) Subcommittee (S-14C), and A-2 on Aircraft and Missile Electrical Equipment.

S-14 members expect to work closely with the IES and the SAE Committees S-7 on Cockpit Standardization and S-9 on Cabin Safety Provisions.

The 1958-1959 SAE Handbook . . .

. . . will be available January, 1959, instead of June, 1958.

REASONS FOR THE CHANGE . . .

(1) To make the Handbook publication date correspond to the calendar year.

(2) Permit technical committee members an October through May work period which is uninterrupted by summer vacations.

(3) Create the effect of advancing the publication date of reports approved by the Technical Board.

The unanimous agreement of technical committee chairmen to use the 1957 Handbook during the 18-month change-over was announced by the Publication Policy Committee in January, 1957.

Technishorts . . .

A STANDARD PROCEDURE FOR DETERMINING RESIDUAL STRESS BY X-RAY is nearing completion in the X-Ray Subcommittee of the ISTC Division 4 on Residual Stresses. The report will cover basic principles and experimental techniques supplemented by several appendices on geometry, absorption, layer removal, and beam penetration. It will also contain a procedure for preparing a hard-stress free-reference specimen. Subcommittee Chairman W. P. Evans, Caterpillar Tractor Co., expects a finished proposal in the near future.

RESULTS OF GENERAL ELECTRIC'S HIGH-TEMPERATURE TESTING OF CHROMEL-ALUMEL THERMOCOUPLES were reported at a recent meeting of Committee AE-2, Temperature Measuring Devices. Thermocouples exposed to an oxidizing atmosphere for 1000 hr at 500, 600, and 700 C showed that within the first 240 hr of test —

At 500 C, the thermocouples changed calibration by approximately 4 C.

At 600 C, calibration changed 5 C.

At 700 C, the change was 8½ C.

In all case, the thermocouples went from a minus 1½-deg deviation from standard to a positive deviation.

AN ARP ON AC MOTOR TACHOMETERS is being developed by a panel of the Aircraft Electrical Equipment Committee. To effect the report, four subgroups were appointed. **Ralph Pickus**, Sperry Gyroscope, is chairman of the Subcommittee on Nomenclature, Definitions, and Equipment Evaluation. **Jack Pinner**, Eclipse-Pioneer, leads the Performance Subcommittee. **C. L. Kennedy**, Sperry Utah Engrg., heads the Physical Dimensions Subcommittee. **E. E. Helander**, Sperry Gyroscope, is chairman of Environmental Requirements Subcommittee.

New Aircraft Lighting Committee To Develop Performance Standards

Nine of the 15 participants at the first meeting of the Aircraft Lighting Committee (S-14) are shown above. (See story on this page.) Left to right: M. A. Mortensen, General Electric; S. R. Morabito, Republic Aviation; F. J. Borofka, Martin Co.; J. G. Hoffman, Hoffman Engineering; S-14 Chairman C. M. Christenson, United Airlines; M. G. Beard, American Airlines; C. L. Crouch, Illuminating Engineering Society; O. G. Henson and P. H. Greenlee, Grimes Mfg. Co.

About SAE Members

CHARLES E. WILSON, at one time president of General Motors Corp. and former Secretary of Defense, has been named to the board of directors of Oswego Navigation Corp., a new entry into the shipping field which has purchased Marine Transport Lines and Marine Navigation Co., Inc., of New York.

MARCUS L. BROWN has retired as president and general manager of Seiberling Rubber Co. of Canada, but will continue as a director of the company. President of Seiberling since 1945, Brown is an active participant in SAE activities. He has been a member of SAE Council, is a past chairman of SAE's Canadian Section, and has worked on many national and Section committees.

ROBERT E. WILSON has retired as chairman of the board of Standard Oil Co. (Indiana). An issue of the company's employee house organ, devoted entirely to Dr. Wilson's striking career, says: "This month, at 65, Dr. Robert E. Wilson becomes a Standard Oil annuitant. Three words — or 3000 — could hardly describe his 36 years of total service, or his 13 years as chairman of the board, during which the company's net worth has doubled."

Dr. Wilson read his most famous technical paper, "Chemical Hay for Mechanical Horses," before SAE. It showed how elaborate and expensive other-than-petroleum power systems for motor vehicles would be.

An SAE member since 1921, Dr. Wilson served for several years on the finance committee.

He will maintain his headquarters in Chicago, give more time to work on the General Advisory Committee to the Atomic Energy Commission and its Weapons Subcommittee . . . also to various foundations and other boards of which he is a member.

W. G. LUNDQUIST has been retained by Reaction Motors Inc., as technical consultant and advisor on the Pioneer rocket engine. Prior to joining the corporation, he had been vice-president, engineering, for all divisions of Curtiss-Wright Corp.

HARRY P. TROENDLY has been elected a group vice-president of Borg-Warner Corp. He had been president of the Spring Division since 1953, and prior to that was vice-president and general manager of the division, which he organized in 1940.

WHITLEY C. COLLINS, president and chief executive of Northrop Aircraft, Inc., has been elected a member of the board of trustees of the California Institute of Technology.

SAMUEL G. RAE has been appointed manager of automotive sales for Owens-Corning Fiberglas Corp. With the corporation since 1950, he most recently has been automotive sales representative for the Detroit branch office.

BERTEL S. NELSON, formerly director of engineering for the Hills-McCanna Co., is now a product design consultant, specializing in the design and development of equipment in the mechanical power transmission field.

SALVATORE F. PISASALE is now a project leader in the research and development department of the Decker Corp. Prior to this he was with the Budd Co. in the airframe research defense department as a senior mechanical engineer, research and development.

G. P. ROBERS, general sales manager, distributor divisions, Fort Wayne Division, Weatherhead Co., will have full charge of the company's "Win With Ermeto" contest.

NORMAN C. WITBECK is now self employed as a technical consultant in the field of aircraft and missile propulsion in Trenton, N.J. Formerly he was chief engineer, Turbo-motor Division, Curtiss-Wright Corp., in Hempstead, L.I., N.Y.

D. E. BARTHOLOMEW has been appointed assistant managing engineer, design, for the heavy truck chassis department, Dodge Division, Chrysler Corp. Formerly he was chassis supervisor for the department. In the same department, **C. J. TAYLOR** has become assistant managing engineer, project engineering. He was formerly a project engineer with Dodge.

RICHARD L. HUMPHREY is now a student at Missouri School of Mines and Metallurgy, working on a B.S. degree in electrical engineering. He has just been released from active duty with the U.S. Army Corps of Engineers.

MARSHALL E. MUNROE, JR., has been made general purchasing manager, North American operations, for Massey-Harris-Ferguson, Ltd., in Toronto. Munroe joined Harry Ferguson, Inc., in 1939, and in 1954 became vice-president in charge of procurement, Massey-Harris-Ferguson, Inc., in Racine, Wis.

JACK SIMON, formerly a hydraulics engineer for the Republic Aviation Corp., is now sales engineer, test equipment, with Greer Hydraulics, Inc.

ROBERT W. GRAHAM is now a senior project engineer in the passenger chassis group, Chevrolet Engineering Center, General Motors Corp. He is responsible for design and release of air suspension on passenger cars. Formerly Graham was a senior experimental engineer in the research and development section.

J. L. CARLISLE has been made senior project engineer in the Body Group at the Chevrolet Engineering Center. Formerly he was group supervisor in the drafting department.

H. H. DONALDSON, JR., has been appointed staff product application engineer in the Marketing Technical Service Division of Gulf Research and Development Co. He will be responsible for coordination of technical service activities pertaining to trucks and buses. Prior to his new appointment, he was with Gulf's Toledo Sales Division.

THEODORE G. VICKERS, formerly manager, manufacturing research and development department for the Kelsey Hayes Co., has been named plant manager for the Ross Operating Valve Co. in Detroit.

JOHN F. CREAMER, JR., has been elected a vice-president of Wheels Inc. He will serve in an executive sales capacity in the same department where he has acted as a field representative during the past four years, and will make his headquarters in Clifton, N. J.

CHARLES R. McCLELLAN has recently become regional sales engineer for Standard Oil Co. of Calif., Western Operations, Inc., in San Francisco. He was formerly district sales engineer for the company in Honolulu. During nine years in the Hawaiian Islands, he held many SAE Hawaiian Section posts.

WILLIAM W. GRAHAM, formerly an industrial automotive engineer with the Utah Oil Refining Co. in Salt Lake City, is now a sales engineer in the Petroleum Additives Division of Amoco Chemicals Corp. in Chicago. The corporation is a newly formed subsidiary of Standard Oil Co. of Indiana.


C. E. Wilson


Brown


R. E. Wilson


Lundquist


Troendly


Collins


Rae


Nelson


Pisasale


Robers

ROBERT W. BURTON is now assistant staff engineer of the transmission, axle, propeller shaft and brake department, Cadillac Motor Car Division of General Motors Corp. Prior to his new appointment, he was senior project engineer with the division.

JOHN S. ANDREWS, formerly regional executive, product manufacturing activities, in the International Division of Ford Motor Co., has been appointed general manager of Fordwerke A.G., Cologne, Germany.

JAMES F. BOURQUIN has become corporate quality manager for the Whirlpool Corp. in St. Joseph, Mich. Formerly he was works manager for the Hamilton Division of the corporation in Hamilton, Ohio.

JERALD D. HINKE is now an experimental engineer with the J. I. Case Tractor Works, Racine, Wis. Formerly he was a powerplant engineer with the Northwest Engineering Co.

HERBERT K. SACHS has become an assistant professor in the College of Engineering, department of engineering mechanics, at Wayne State University in Detroit. Formerly he was supervisor of engineering computations at the level of senior project engineer, with the truck and coach engineering department, General Motors Corp.

JAMES W. SINCLAIR has retired as manager, automotive department, Union Oil Co. of Calif. He is a past-chairman of SAE Southern California Section.

WALTER L. FLINN, formerly manager of Vickers Aero Hydraulics Division, Sperry Rand Corp. in Washington, has been appointed staff director — defense activities, for Vickers.

CRAY L. FOLEY is now a research engineer for the Lockheed Missile System Division of Lockheed Aircraft Corp., Sunnyvale, Calif. Formerly he was an engineer with the Sperry Gyroscope Co. in Great Neck, N. Y.

S. K. CANNON has been transferred to the Atlanta Assembly Plant of Ford Motor Co. in the capacity of assistant plant manager. Prior to this he was assistant to the plant manager, Ford Division, Ford Motor Co., in the Mahwah Assembly Plant.

R. F. LABORY is now division automotive superintendent with the Union Oil Co. of Calif. Previously he was assistant to the manager, automotive department, with the same company. He has been active in SAE Southern California Section and was vice chairman of the Section's Transportation and Maintenance Activity for 1956–57.

ERNEST ERWIN has been transferred to Marietta, Georgia division of Lockheed Aircraft Corp., as director of quality control. Formerly he was chief inspector for the corporation in Burbank, Calif.

FRANK E. PILLING, JR., is now general sales manager for the Marvel-Schebler Products Division of Borg-Warner Corp. in Decatur, Ill. Prior to this he was manager of liquefied petroleum gas carburetion equipment for the Century Gas Equipment Co. until it was purchased by Marvel-Schebler. He has been active in SAE Southern California Section.

WILLARD J. RUSSELL, formerly vice-president, director of sales, Fruehauf Trailer Co. of Canada, Ltd., is now vice-president and director of sales, Trailer Division, with Canadian Car Co., Ltd.

FARRALD G. BELOTE, SR., has become district manager for Allied Automotive Parts Co. in Cincinnati. Prior to this he was sales engineer with the American Brake Shoe Co. in Detroit.

ARTHUR R. CHASE is now maintenance officer, post ordnance, Headquarters U.S. Army Garrison, Post Ordnance Section, in Colorado. Formerly he was with the Ordnance Division of the Army in Hawaii.

A discussion of automation principles as practiced in the automotive industries was presented by **JOSEPH GESCHELIN**, Detroit Editor, Chilton Publications, at the Regional Conference of the National Management Association in Cincinnati, April 12, 1958.

The talk developed the basic concepts of automation; its advantages and limitations; and traced the background leading to the adoption of such techniques by automotive manufacturers. Typical installations in machine shops, press shops, and in assembly departments were illustrated to indicate the form and application of automation devices.

JORGEN J. VOLTELEN represented Denmark at a meeting on motor vehicle construction requirements held in March in Geneva, Switzerland, under the auspices of the Economic Commission for Europe. Voltelen is chief commissioner, Motor Vehicle Technical Department of the Danish Ministry of Justice. **RALPH BERTSCHE,** electrical engineer of the Truck and Coach Division, General Motors Corp., and **DON BLANCHARD,** of the SAE Staff, were industry members of the U.S. State Department Delegation to the meeting.

W. E. JOMINY, chief metallurgist, research, Chrysler Corp., is among top-ranking metallurgists appointed to positions on the newly created National Advisory Council of the Metals Engineering Institute.

Members of the executive committee of the Automotive Old Timers, selected by the board of directors from its membership, are as follows:
WILLARD F. ROCKWELL, chairman, Rockwell Spring and Axle Co., honorary president and life director; **A. W. HERRINGTON,** chairman, Marmon-Herrington Co., president; **JOHN F. CREAMER,** president, Wheels, Inc., vice-president; **GEORGE A. MARTIN,** president, Town and Country Motors Inc., vice-president, and **ALFRED REEVES,** consultant, Automobile Manufacturer's Association, vice-president.

The officers were elected at the 18th Annual Meeting.

WILBUR L. CROSS, JR., has been named chairman of the Committee on Engineering and Vehicle Inspection of the American Association of Motor Vehicle Administrators. He is with the Connecticut Department of Motor Vehicles.

CHARLES M. HEINEN, of Chrysler Corp., has been elected chairman of the Vehicle Combustion Products Committee of the Automobile Manufacturers Association. He replaced **JOHN M. CAMPBELL,** of General Motors Research Staff. **JAMES M. CHANDLER,** of Ford Motor Co., serves as vice-chairman of the committee.

CONTINUED ON NEXT PAGE

Taylor Butler

J. E. TAYLOR, formerly director of the Automotive Engineering Division, Gulf Research and Development Co., has been appointed director, Automotive Research. Taylor, who has been with Gulf since 1934, will have his office in Birmingham, Mich., and will also maintain an office at the Gulf Research Center for periodic consultations with the research staff.

Taylor is succeeded as director of the Automotive Engineering Division by CHARLES W. BUTLER, who was formerly assistant to the director of the division. Butler, who has been with Gulf Research since 1933, will be responsible for directing activities of personnel engaged in research on the company's automotive and aviation products.

WAYNE H. MUELLER is now a project engineer with the Owosso Division of Midland-Ross Corp. in Owosso, Mich. Formerly he was a project engineer with the Farnsworth Electronics Co. in Ft. Wayne, Ind.

ROBERT F. PETERJOHN, formerly field engineer with the Weatherhead Co. in Glendale, Calif., is now chief engineer for the Aircraft Fitting Co. in Dania, Fla. He is responsible for all engineering, tool design, field service, and research and development.

WILL W. WHITE, formerly vice-president, Esso Research and Engineering Co., is now director and aviation coordinator with the Esso Export Corp. He is responsible for coordination of Standard Oil Company's worldwide aviation petroleum activities.

EDGAR S. CHEANEY, formerly a designer with Allis Chalmers Mfg. Co., Springfield, Ill., is now research project engineer for Battelle Memorial Institute in Columbus, Ohio. He is in charge of development projects in the Product Research Division. Cheaney has been active in SAE Central Illinois Section.

PAUL T. HUGHES, formerly supervisor of stores and automotive operations, Southern Counties Gas Co., Los Angeles, is now superintendent of maintenance for Burlington Truck Lines, Inc., Galesburg, Ill. He is responsible for the direction and maintenance of the entire fleet.

PAUL R. LEPISTO, formerly project engineer for International Harvester Co., Ft. Wayne, Ind., is now senior engineer for Chrysler Corp. His work involves the testing and development of trucks.

CARL O. MONROE, formerly district service supervisor for International Harvester Co., is now branch industrial sales manager for Massey-Harris-Ferguson, Inc., Industrial Division. With his headquarters at Jackson, Miss., he is responsible for branch operation of the company's industrial products in a three-state area. Monroe has been active in SAE Mid-Continent and Wichita Sections.

E. R. NOBLE has become area fleet sales manager for Chrysler Motors Corp. in New York City. He handles all fleet sales in the eastern marketing area, covering the Philadelphia, New York, and Boston zones. Formerly Noble was regional manager for the Fargo Division of the corporation in Bala Cynwyd, Pa.

WILLIAM E. POWELL is now Airide sales engineer for Firestone Industrial Products Co.; previously he was unit supervisor in the development department of Ford Motor Co.

ROBERT B. BUTLER, formerly sales manager, AiResearch Industrial Division of the Garrett Corp., is now industrial sales manager for the Sargent Engineering Corp. He is engaged in development of industrial applications for the company's precision products, and design and development facilities.

ROBERT G. HARDIN, formerly sales engineer for Gulf Oil Corp. in Richmond, Va., is now a technical analyst in the product application department of the corporation in Pittsburgh, Pa.

RAYMOND A. HUDSON is now sales engineer for the Chicago Rawhide Mfg. Co.; formerly he was sales engineer for the National Seal Division of Federal-Mogul-Bower Bearings Inc.

SURENDRA P. PATEL, formerly design engineer for the Caterpillar Tractor Co. of Great Britain, Ltd., is now with the Caterpillar Tractor Co. of Peoria, Ill. His work includes performance analysis of diesel engines; thermal loading and wall temperature of turbocharged compression-ignition engines.

AUGUST H. LEU, formerly sales manager, E. Blankenship & Co., Inc., Marion, Ill., is now sales manager, Automotive Division, Shatterproof Glass Corp., Detroit, Mich.

L. L. NORMAN, formerly editor, National Market Reports, Inc., Chicago, Ill., is now general manager of the Glenn Mitchell Catalog Service in San Diego, Calif.

GENE R. DREW, formerly assistant field operations supervisor, Project S.M.A.R.T., Coleman Engineering Co., is now test engineer for the Grand Central Rocket Co. His work includes testing, research, and development on solid propellant rocket motors and rockets.

GEORGE W. GIBSON, JR., formerly assistant chief engineer, Dodge Division, Chrysler Corp., is now staff engineer, automotive group, with Chrysler. His work includes administration and coordination of product engineering projects for the automotive group.

OSCAR BROMBERG, formerly an engineer with Bromberg, Staudt and Co. in Hamburg, Germany, is now in the engineering department of Máquinas Bromberg, Ltda., in São Paulo, Brazil. His work includes sales contacts; technical consulting for industry and government; and design and layout of industrial installations, hydraulic and electric stations.

ORVIS J. FAIRBANKS, formerly manufacturing engineer for the Western Electric Co., Winston Salem, N. C., is now a technical consultant for the government of Yugoslavia, in Belgrade. He provides consulting service on technical problems throughout Yugoslavia at various industrial locations.

LEE R. SCOTT, JR., is now scientist A: — thermodynamics, with the Hayes Aircraft Corp. in Birmingham, Ala. Formerly he was a thermodynamicist with the AiResearch Mfg. Co. of Arizona, division of the Garrett Corp., in Phoenix.

MARTIN HEBERT, JR., formerly supervisor, advanced systems, Aircraft Gas Turbine Department, General Electric Co., is now supervisor, Instrumentation Division unit, Aircraft Nuclear Propulsion Department, for the company.

FRANCIS MANGIN, formerly an engineer with the Grumman Aircraft Engineering Corp. in Bethpage, N. Y., is now with the Office of Naval Research at the U.S. Naval Training Device Center, in Port Washington, N. Y.

EARL D. ALLEN, formerly a refrigeration engineer with the Norge Division of Borg-Warner Corp., Muskegon Hts., Mich., is now a tool designer — A, for the McDonnell Aircraft Corp. in St. Louis, Mo.

CHARLES J. KEIM, formerly chief engineer of the Oil Well Supply Division of U.S. Steel Corp., is now director of product research and development with the same division.

THOMAS A. KESEL, formerly in the U.S. Army at Aberdeen Proving Grounds, is now an engineer with central engineering of Chrysler Corp.

STANLEY L. MACKLIS has become supervisor — controls component design, for the Aircraft Gas Turbine Division of the General Electric Co. in Cincinnati. Prior to this he was senior project engineer for the New York Air Brake Co.

JOHN S. GABEL, formerly industrial engineer for E. I. duPont de Nemours & Co., Inc. in Wilmington, Del., is now engineering director for Martin Century Farms, Inc., in Lansdale, Pa.

LAWRENCE E. GAYDOS, formerly a research engineer on the engineering staff of Ford Motor Co., is now a project engineer with the U. S. Army Ordnance Corps, Detroit Arsenal.

ALBERT OLSON is now consulting management engineer with George S. May Co. de Venezuela, CRL. Prior to this he was a consulting engineer in Toronto.

JOSEPH T. REAM, JR., has joined Atomics International Division of North American Aviation, Inc., as senior research engineer. Previously he was systems engineer with the Nuclear Systems Group of AiResearch Mfg. Co. of Ariz.

WILLIAM A. KUHN has become research engineer with the Research Division of the Micromatic Hone Corp. in Palmdale, Calif. Formerly he was group supervisor, special products section, Aero-Hydraulics Division, Vickers, Inc., in Detroit.

CHARLES H. JACKSON has joined the staff of the electronics department of Hamilton Standard, Division of United Aircraft Corp., as a project engineer in the advanced design group. Jackson formerly was with General Electric's heavy military electronics department as a systems analyst specialist, in the field of radar; prior to this, he worked for the U.S. Navy Bureau of Ordnance as a guided missile project engineer.

STANLEY L. BUCKAY, formerly section engineer, General Motors Corp., engineering staff, transmission development section, Technical Center, is now with the Buick Motor Division, research and development section, engineering department, GMC.

CHARLES E. SCHEFFLER, JR., formerly assistant head, automotive engines department, General Motors Research Staff, General Motors Corp., is now with the General Motors engineering staff, power development department, GM Technical Center.

ROBERT P. WOLFE, formerly assistant product development engineer, International Harvester Co., Phoenix, Ariz., is now product development engineer for the company, Huntsville Proving Ground, Construction Equipment Division, in Huntsville, Mo.

HANS U. WYDLER is now assistant secretary for the Chemical Corn Exchange Bank. Formerly he was vice-president in charge of Value Line Investor's Counsel, Inc.

RAYMOND P. MARTIN, JR., is now associate engineer — weapons support equipment, Pilotless Aircraft Division, Boeing Airplane Co., in Seattle, Wash. Formerly he was junior design engineer — cabin pressure — AiResearch Mfg. Co., division of The Garrett Corp., Los Angeles.

RICHARD T. NOÉ, formerly manager, advanced design analysis, styling office, Ford Motor Co., is now chief staff engineer, research and development, with Canadair Ltd., in Montreal, Can.

DANIEL GRUDIN, formerly senior staff engineer, Stroukoff Aircraft Corp., is now project engineer, new product development, Propeller Division, Curtiss-Wright Corp.

JOHN G. SPRUHAN is now vice-president and general manager for the Townsend Co., Dunn Steel Products Division, Plymouth, Mich. Formerly he was central division sales manager for the company until 1953, when he became general manager.

DAVID R. OSBORNE, formerly production engineer for the New Process Gear Division of Chrysler Corp., is now laboratory supervisor in charge of the Dodge truck line with the corporation.

BENJAMIN G. GRAY, formerly an instructor of automotive technology at Gaston Technical Institute in Gastonia, N. C., is now a lubrication engineer, automotive, for the Texas Co. in Norfolk, Va. His position includes checking on application and use of petroleum products by the truck and bus fleets of the transportation industry, and the motoring public.

ROY V. NORRLANDER is now section engineer in charge of the Design Support Section for Texas Instruments, Inc., in Dallas. Formerly he was section engineer in charge of high pressure hydraulics for the Lear-Romec Division of Lear, Inc., in Elyria, Ohio.

JOSEPH J. W. MORRISON, formerly machine supervisor for Canadian Marconi Co., Ltd., St. Johns, Newfoundland, Can., is now machinist erector foreman for Flanders Installations, Ltd. in Vancouver, B. C., Can.

THOMAS R. KIRKMAN, formerly assistant chief engineer for the Conco Engineering Works in Mendota, Ill., is now plant manager for the Zero Mfg. Co. in Burbank, Calif.

JERE T. FARRAH has been named assistant vice-president — engineering of Seaboard & Western Airlines, Inc. The post, a new one in the organization, will involve coordination of various branches of the engineering department, which is being expanded to include performance, airframe, and powerplant engineering. Farrah, formerly manager of the powerplant and accessory overhaul shop of American Airlines, Inc., in Tulsa, Okla., has been with Seaboard & Western since 1942.

DANIEL CHIEGER has been appointed director of engineering for the automotive divisions of Young Spring & Wire Corp. He will head the company's product development, tooling, and plant engineering projects in the automotive field. Chieger joined Young as a member of the metallurgy department in 1942, and has been in charge of sales engineering since 1955.

GEORGE W. MICHEL, formerly an automotive engineer with Clark Equipment Co.'s Transmission Division, is now product supervisor for Yard-Man, Inc., Jackson, Mich.

EUGENE S. LUBARSKY, formerly senior research engineer for the Socony Mobil Oil Co., research and development labs in Paulsboro, N. J., is now staff engineer in the Product Engineering Division of the company in New York City. He is responsible for present quality protection and future quality planning on motor gasoline and aviation fuels for the marketing department.

FRED L. HALL, formerly division manager for the Fruehauf Trailer Co. in Boston, Mass., is now with the Trailer Division of Aerobilt Bodies, Inc., Athens, N. Y., a subsidiary of Grumman Aircraft Engineering Co. In his new position as general sales manager, he is engaged in the development of a sales and service organization for a line of new trailers. Hall has been an active member of SAE for 25 years.

R. C. CROSS, managing director, Cross Mfg. Co., Ltd., has been appointed chairman of the Automobile Division of the Institution of Mechanical Engineers for 1957–1958.

THOMAS BOWLING has been named to the new position of director of field support for turbine engines, Continental Aviation and Engineering Corp. He had been administrative assistant to the executive vice-president of the corporation.

WILLIAM P. LEAR, SR., founder and chairman of the board of Lear, Inc., has been elected to the board of directors of Pacific Airmotive Corp.

CONTINUED ON NEXT PAGE


Kulose


O'Connell


Greathouse


Cuthbert


Kartisek


Jacobsen


Gruitch


Herz


Edsall


St. George


Keller


Francis


Hutchinson


Root


Terry

H. B. KULOSE, chief engineer of Huppower, a division of Hupp Corp. has been elected the first president of the newly formed American branch of the Society of German Engineers. The purpose of the branch is to "establish connections and cooperation in the engineering field among engineering societies and technical enterprises in the U. S. and Germany."

JAMES O'CONNELL has been appointed chief inspector at Freightliner Corp.; prior to this he was maintenance research and development engineer with the corporation.

JACK F. GREATHOUSE, new development supervisor, Engine Division, Mack Trucks, Inc., has won the John Woodman Higgins Redesign Award for 1958. His new engine manifold design saves nearly 12 pounds in weight and 40 per cent in cost.

HARRY CUTHBERT has joined Hercules Motors Corp. as assistant chief engineer for the new line of air-cooled engines. Previously he was chief engineer of the Lycoming Industrial Engine Division of Avco Mfg. Co.

THOMAS E. KARTISEK is now in field service and sales for Miehle-Dexter Supercharger Division of the Christensen Machine Co. Prior to this he was a project engineer with the division.

CARL A. JACOBSEN continues with Miehle-Dexter as chief engineer.

JERRY M. GRUITCH, director of research and development for the American Car and Foundry division of ACF Industries, Inc., will assume the newly created post of director of defense products. He continues as advisor to the division's research and development department.

GLENN HERZ has been made chief engineer of the Hyster Co. Assistant chief engineer for the past five years, he has been with the company for 12 years.

BRUCE EDSALL has been made staff engineer in charge of transmissions, axles, propeller shafts, and brakes, for the Cadillac Motor Car Division of General Motors Corp. Prior to his new position he was assistant staff engineer for the division. He replaces **GEORGE L. ROTHROCK**, who is retiring after 33 years service with Cadillac. Rothrock had been instrumental in the development of Cadillac's power train.

A. J. St. GEORGE, formerly manager of the Chicago branch of the Ensign Carburetor Co., has been appointed sales manager. He joined the company in 1937 and will now make his headquarters at the company's principal offices in Fullerton, Calif.

Succeeding St. George as Chicago Branch manager is **GRANT W. KELLER**, field engineer, who has served Ensign's eastern clientele out of Chicago for the past ten years.

HAROLD E. FRANCIS, former assistant chief engineer of Wright Aeronautical Division, Curtiss-Wright Corp., has been named senior staff engineer of Chandler-Evans Division of Pratt & Whitney Co.

ROLAND V. HUTCHINSON has retired as special assistant to **CHARLES A. CHAYNE**, vice-president in charge of the engineering staff, General Motors Corp. A native of England, Hutchinson came to the U.S. in 1910; in 1916, he joined Dayton Metal Products Co., which later became GM Research Staff. Until August, 1957, he was head of GM engineering staff's automotive ordnance section of vehicle development group.

EARL R. FISH retires as chief engineer of the Machine Tool Division of Lipe-Rollway Corp., and has been named consulting engineer for the corporation. He is succeeded by **ROBERT S. ROOT**, who has been appointed chief engineer of both the Clutch Division and Machine Tool Division. Root joined W. C. Lipe Inc. in 1938 as a design engineer, and has been chief engineer of the Clutch Division of Lipe-Rollway since 1953.

LeGRAND TERRY has been made district manager for the mobile section, Detroit office of Vickers Inc., a newly established sales department. Terry has been with Vickers since 1951 and most recently has worked in mobile product sales.

CARLETON H. SWANSON, formerly with the Clinton Machine Co., Maquoketa, Iowa, in an engineering capacity, is now production engineering manager for the Eaton Mfg. Co. in Battle Creek, Mich.

RICHARD J. CRANE is now contracting officer and contract office head, Advanced Nuclear Bomber Weapons System Office, Directorate of Procurement and Production, Headquarters Air Materiel Command, Wright-Patterson Air Force Base, in Dayton, Ohio. Prior to this he was contractor administrator for Temco Aircraft Corp. in Dallas, Tex.

CLAY BALLINGER, formerly works manager with the Marmon-Herrington Co. in Indianapolis, is now industrial management advisor with the United States Delegation to NATO and the Organization for European Economic Cooperation.

W. HERMAN BARCUS, formerly manager of the Product Development Division of Sun Oil Co., is now manager of a new Research Service Division. Barcus has been with the company nearly 30 years and became manager of the Product Development Division in 1953. He is succeeded in this position by **ROBERT W. DONAHUE** who has been with Sun since 1941 and was named section chief in 1953.

RAYMOND J. TUSHAR has been made sales engineer for the Iron Fireman Mfg. Co. Formerly he was sales engineer for the eastern district of Clevite Harris Products Co., Inc.

CHARLEY E. BENGTSSON has become chief engineer for International Harvester Maquinas, South America, in Sao Paulo, Brazil, where he will be in charge of the product engineering department. Prior to this he was assistant chief engineer for the International Harvester Co., of Great Britain, Ltd., in Doncaster, Yorkshire, England.

DON W. MORRISON is now a mechanical engineer with the Interstate Commerce Commission, Bureau of Motor Carriers, Section of Safety, in Washington, D.C. Prior to this he was with the St. Louis Division of Combustion Engineering, Inc.

LOUIS GLIST, formerly real estate representative for the Shell Oil Co. in Seattle, is now sales supervisor for the company in Los Angeles.

EDGAR J. van DYK has joined Control Devices, Inc., as general manager. Formerly he was in sales engineering with the Detroit Diesel Engine Division of General Motors Corp.

ALLAN G. SHEPPARD has become vice-president in charge of engineering and development for the American-LaFrance Corp. Prior to this he was director of engineering with the corporation.

WINTON J. PELIZZONI is now executive engineer in the engine design department of Mack Trucks, Inc., and is in charge of all gasoline and diesel engine design and development. Formerly he was assistant executive engineer with the corporation.

LINWOOD W. WHITE is now parts manager with the Washington Factory Branch of Mack Trucks, Inc. Formerly he was service and parts manager with the Reo Division of White Motor Co. in Richmond, Va.

ROBERT E. DILLING, formerly sales representative with E. W. Bliss Co., has joined Harron, Rickard & McCone Co., in the same position.

ALF HUNDERE, formerly department chairman for the Southwest Research Institute, has become president of Alcor, Inc., San Antonio, Texas.

FRANK W. CROOK is now with Sanders Associates, Inc., in Nashua, N. H., in systems marketing. Prior to this he was a sales engineer for Wright Aeronautical Division of Curtiss-Wright Corp.

JOHN H. EATON has become a research assistant (student) in the Fluid Power Control Laboratory of the Massachusetts Institute of Technology. Previously he was an experimental engineer with Pratt & Whitney Aircraft Division, United Aircraft Corp., in Florida.

JOHN W. WYATT, JR., formerly regional radio representative, Chevrolet Motor Division, General Motors Corp., Kansas City, Mo., is now district manager for the division in Memphis, Tenn.

WILLIAM LUTHI, formerly product engineer, Standard Oil Co., has joined the Elco Lubricant Corp. as technical sales representative.

The Parker Rubber Division and the Franklin C. Wolfe Division of Parker-Hannifin Corp. in Cleveland have recently been combined under the name of the Parker Seal Co.

Administrative headquarters of the new division will be in Culver City, Calif., under the direction of **PAUL F. SMITH**, general manager. Smith had been general manager of the Franklin C. Wolfe Division.

SCOTT A. ROGERS, assistant general manager of the new division, will continue in Cleveland with direct responsibility for eastern operations. Formerly he had been manager of the Parker Rubber Division.

T. J. McCUISTION, formerly sales manager of the Parker Rubber Division, will serve in the same capacity for the new division, with headquarters in Cleveland.

ALBERT L. WEEKS has become director of manufacturing with Cockshutt Farm Equipment Ltd. Prior to this he was director of manufacturing, Massey-Harris-Ferguson Ltd., in London.

CHARLES R. MILLER is now assistant to the sales manager with the National Refining Co., a division of Ashland Oil & Refining Co., in Cleveland. Prior to this he was with Ashland as a technical service engineer in Ashland, Ky.

ERIC SCHWARZ has become sales manager with A. O. Smith International, South America, in Caracas, Venezeula. Prior to this he was with the corporation's International Division in Milwaukee, Wis.

H. R. BOATMAN is now assistant superintendent, Chicago Division, service department, quality control, for the Inland Steel Co. Prior to this he was supervisor, bars, plates, and shape products, with Inland.

J. TERRY TAYLOR is now with the B. F. Goodrich Tire Co. in Akron, Ohio, as manager, product service and field engineering. Prior to this he was manager, fuel cell operations, for B. F. Goodrich Aviation Products in Los Angeles.

PAUL E. HOVGARD, formerly vice-president of Kellett Aircraft Corp., has been named assistant to the president of Helio Aircraft Corp., and will make his headquarters in Pittsburg, Kan.

RUSSELL H. WHEMPNER has been named western sales manager for the Minneapolis-Honeywell Regulator Co. He had been director of service engineering and sales manager for the Aeronautical Division since 1945.

HARVEY R. SMITH, formerly vice-president, manufacturing, with Avro Aircraft, Ltd., Toronto, is now vice-president and general manager for the Dosco Steel Fabrication and Mfg. Division, Dominion Steel and Coal Corp., Montreal, Quebec, Canada.

PAUL G. HYKES, executive engineer, Budd Co., has been named president of the Tire and Rim Association.

Obituaries

CLINTON R. BOOTHBY . . . (M'52) . . . chief electrical engineer, the Electric Auto-Lite Co. . . . joined the company in 1938 . . . died Jan. 28 . . . born 1900 . . .

HERDIS G. ENGLISH . . . (M'47) . . . chief engineer, Ford Motor Co., transmission and axle group, product engineering office . . . had been with the company since 1950 . . . died Feb. 20 . . . born 1914 . . .

J. NELSON FREY . . . (A'53) . . . specifications and test manager, Thomas & Betts Co. . . . had been with the company since 1947 . . . died January . . . born 1903 . . .

R. L. HUMBERT . . . (M'24) . . . research engineer, Kohler Co. . . . had been with the company since 1922 . . . died Feb. 24 . . . born 1891 . . .

J. CONRAD JOHNSON . . . (A'49) . . . president, Johnson Motor Sales, Inc. . . . started in the auto business 1909 . . . operated Johnson since 1934 . . . died Feb. 24 . . . born 1892 . . .

GEORGE A. KOPATZKE . . . (A'43) . . . branch manager, Wagner Electric Corp. . . . had been with Wagner since 1921 . . . died Dec 8 . . . born 1904. . . .

ARTHUR G. MORAN . . . (M'43) . . . automotive engineer, Code ES-36, Department of the Navy, Bureau of Ordnance . . . had been with the Navy Department since 1949 . . . died Mar. 4 . . . born 1898. . . .

VALDEMAR A. NIELSEN . . . (M'16) . . . retired New England representative for the Bear Mfg. Co. . . . Past chairman, SAE New England Section, 1924–25 . . . died Feb. 28 . . . born, Denmark, 1883 . . .

HOWARD K. PIKE . . . (M'46) . . . vice-president, maintenance and engineering, National Airlines, Inc. . . . had been with National since 1941 . . . died Feb. 21 . . . born 1916 . . .

Over 60 Papers to be Printed In 1958 SAE Transactions

THE 1958 SAE Transactions will be published in August, according to present production plans. It will include over 60 papers presented at national and section meetings of the Society in the last year and a half. Any written and oral discussion of an author's presentation will be also printed with the paper.

Prices of the book are: $3 to members, $7 to libraries and U. S. Government agencies, and $10 to nonmembers; foreign: $3 to members, $8 to libraries, and $11 to nonmembers.

The papers approved thus far for publication by one or more of the 20 Readers Committee include:

"Fumigation Kills Smoke, Improves Diesel Performance"—by **M. Alperstein, W. B. Swim, and P. H. Schweitzer**

"Bifuel Approach to Burning Residual Fuels in Diesel Engines"—by **W. C. Arnold, R. H. Beadle, R. L. Legelin, and H. D. Young**

"Valve Train Wear as Affected by Metallurgy, Driving Conditions, and Lubricants"—by **Vincent Ayres, J. B. Bidwell, A. C. Pilger, Jr., and R. K. Williams**

"Aircooled Diesel Engine Appraisal"—by **C. F. Bachle**

"Protective Atmospheres for High-Temperature Bearing Operation"—by **C. H. Bailey, S. S. Serem, and A. G. Cattaneo**

"Principles of Noise Reduction"—by **L. M. Ball**

"Continuous Radiotracer Monitoring Shows How Piston Rings Wear in Service"—by **J. S. Batzold, J. V. Clarke, and J. F. Kunc**

"The Air Coil Spring"—by **W. S. Berry**

"Torque Converters Can Be Different"—by **J. B. Black and M. W. Dundore**

"Engineering the Edsel"—by **N. L. Blume**

"Shell Molded Cast Crankshafts"—by **H. N. Bogart and H. C. Grant**

"Autoignition Associated with Hot Starting"—by **F. W. Bowditch and R. F. Stebar**

"Diesel Cylinder Heat Transfer Design Criteria"—by **D. H. Brown**

"Vapor Locking Tendencies of Fuels—A Practical Approach"—by **J. D. Caplan and C. J. Brady**

"Automotive Exhaust Hydrocarbon Reduction during Deceleration by Induction System Devices"—by **H. H. Dietrich and Induction System Task Group of Automobile Manufacturers Association**

"Chrysler Torsion-Aire Suspension—Across the Board"—by **O. D. Dillman and R. R. Love**

"Resilient Face Seals for Tractor Final Drives"—by **F. S. Engelking and M. C. Keys**

"Problems in the Application of High-Strength Steel Alloys in the Design of Supersonic Aircraft"—by **A. F. Ensrud**

"Effects of Radiation on Materials"—by **Michael Ference, Jr.**

"Determination of True Engine Friction"—by **R. E. Gish, J. D. McCullough, J. B. Retzloff, and H. T. Mueller**

"Design Features of the New Ford Axle"—by **Bain Griffith**

"Large Lightweight Turbojet Engines"—by **C. A. Grinyer**

"1958 Chevrolet Level Air Suspension"—by **K. H. Hansen, J. F. Bertsch, and R. E. Denzer**

"Tractor Hydraulics, Good Field, No Hit"—by **G. L. Hershman**

"The System of the MWM Balanced Pressure Precombustion Chamber for High-Speed Diesel Engines"—by **Hans L. Hockel**

"Visual Avoidance of Mid-Air Collisions"—by **W. D. Howell and R. B. Fisher**

"The Chrysler Torque-Flite Transmission"—by **S. D. Jeffe and B. W. Cartwright**

"The Beam Strength of Modern Gear Tooth Design"—by **B. W. Kelley and R. Pedersen**

"Metallurgical Design Consideration for Precipitation-Hardening Steels up to 1200 F"—by **F. K. Lampson**

"Rear Axles—Today—Tomorrow"—by **R. P. Lewis and L. J. O'Brien**

"Measurement of Gas Temperature in an Engine by the Velocity of Sound Method"—by **J. C. Livengood, C. F. Taylor, and P. C. Wu**

"Requirements, Parameters, and Design Considerations for Pneumatic Inlet Control Systems"—by **R. E. Matzdorff and C. F. Newberry**

"Turbocharging the Series 71 Engine"—by **J. J. May and V. C. Reddy**

"The Buick Air-Poise Suspension"—by **F. R. McFarland, E. C. Peckham, and E. Dietrich**

"Bio-Technical Aspects of Driver Safety and Comfort"—by **R. A. McFarland and R. G. Domey**

"The Cadillac Frame—A New Design Concept for Lower Cars"—by **S. L. Milliken and J. R. Parker**

"Designing with Steel for Lighter Aircraft"—by **Bruce Mitchell**

"Mathematical Correction for Stress in Removed Layers in X-Ray Diffraction Residual Stress Analysis"—by **M. G. Moore and W. P. Evans**

"The Future of the Free-Piston Engine in Commercial Vehicles"—by **O. B. Noren and R. L. Erwin**

"Automotive Gasoline Injection"—by **C. H. Nystrom**

"Simulation of a Free-Piston Engine with a Digital Computer"—by **D. R. Olson**

"The Ford Approach to Air Suspension"—by **C. F. O'Shea**

"Oldsmobile New-Matic Ride"—by **R. W. Perkins**

"Rear-Engine Motor Cars—the European Point of View"—by **Fernand Picard**

"Cadillac's Air Suspension for the Eldorado Brougham"—by **V. D. Polhemus, L. J. Kehoe, Jr., F. H. Cowin, and S. L. Milliken**

"Designing Materials for Future Aerial Vehicles"—by **N E. Promisel**

"Bearing Application for Heavy-Duty Axles"—by **R. M. Riblet and C. M. Kitson**

"High-Temperature Properties of Vacuum-Melted Superalloys"—by **F. M. Richmond**

"Investigating Combustion Phenomena in Unmodified Engines"—by **J. A. Robison, M. D. Behrens, R. C. Mosher, and J. M. Chandler**

"Thrust Measurement for Jet Transport Operation"—by **M. J. Saari**

"Mercedes-Benz Racing Cars—Design and Experience"—by **H. Scherenberg and J. E. Witzky**

"Combustion Chamber Deposits—A Radiotracer Study"—by **L. B. Shore and K. F. Ockert**

"Use of Temperature-Density for Measuring Antiknock Quality"—by **Bruno R. Siegel**

"Behavior of Aircraft Structures under Thermal Stress"—by **C. H. Sprague and P. C. Huang**

"Truck Performance—Computed versus Measured Data"—by **A. F. Stamm**

"The Effects of Machine and Foundation Resilience and of Wave Propagation on the Isolation Provided by Vibration Mounts"—by **A. O. Sykes**

"Loop Scavenging versus Through Scavenging of Two-Cycle Engines"—by **C. F. Taylor, A. R. Rogowski, A. L. Hagen, and J. D. Koppernaes**

"Some Metallurgical Aspects of Pontiac V-8 Engine Pearlitic Malleable Iron Crankshaft"—by **K. B. Valentine**

"Considerations of Some Jet-Deflection Principles for Directional Control and for Lift"—by **U. H. von Glahn and J. H. Povolny**

"The Chevrolet Turboglide Transmission"—by **F. J. Winchell, W. D. Route, and O. K. Kelley**

"The Improvement of Welded Structures by Subsequent Forging Operations"—by **W. R. Wolfering and E. H. Lundby**

1958 SAE National Meetings

• June 8-13
Summer Meeting,
Chalfonte-Haddon Hall,
Atlantic City, N. J.

• August 11-14
West Coast Meeting,
Ambassador,
Los Angeles, Calif.

• September 8-11
Farm, Construction and Industrial Machinery, Production Forum, and Engineering Display,
Milwaukee Auditorium,
Milwaukee, Wis.

• September 29-October 4
Aeronautic Meeting,
Aircraft Production Forum, and Engineering Display,
Ambassador, Los Angeles, Calif.

• October 20-23
Transportation Meeting,
Lord Baltimore Hotel,
Baltimore, Md.

• October 21-24
Diesel Engine Meeting,
Lord Baltimore Hotel,
Baltimore, Md.

• November 5-6
Fuel and Lubricants Meeting,
The Mayo, Tulsa, Okla.

Missiles Advisory Committee Issues Newsletter

To help acquaint members — and membership prospects—of SAE's part in the missiles field, an "SAE Missiles Newsletter" has been issued by Frank Fink, Chairman of the Missiles Advisory Committee.

"SAE Missiles Newsletter" includes items of general interest on the Society's program and plans linked to the many aspects of missiledom—components, fuels, ground equipment, and the missiles. Papers and panel discussions on National and Section level, publications and the work of Activity Committees and Technical Committees specializing in this area—are among points covered.

Copies are available by writing SAE Headquarters, 485 Lexington Avenue, New York 17, N. Y.

Exhaust Studies Raise New Queries

Based on paper by

GILBERT WAY
Ethyl Corp.
and
W. S. FAGLEY
Chrysler Corp.

An extensive survey in Los Angeles to measure exhaust emissions from a representative group of cars answered a good many questions . . . and raised a good many more. It showed that there still are wide variations in reported values. It showed also that reasons for the variations must be established before definite conclusions can be drawn about absolute hydrocarbons in exhausts.

A study of reported values to determine the area of greatest confidence in the data indicates CO and CO_2 data have the greatest accuracy. Comparison with Orsat analyses shows reasonable agreement after correcting infrared values from the wet basis to the dry basis.

Airflow measurements also show reasonable values, but are not quite as accurate at low flows as desirable. The calibration deflection used kept high airflows on the chart and reduced the deflections correspondingly for low flows.

Hydrocarbon data presents the same problem as the airflow data. Low concentrations at cruise and acceleration have small deflections in order to retain the peak values during deceleration.

Prior to the field survey and following it, a large amount of data was obtained in connection with other studies.

In general, data obtained in the laboratories by the various participating companies have indicated substantially lower emissions at cruise and idle than were observed during the field survey. In some cases, the values during these cycles have been ¼ as large as those reported from the survey.

Although considerable work has already been done, no complete explanation for these differences has been established.

Several areas for further explanation are indicated. For instance, although the best sampling techniques known at the present time (for field-type tests) were used in the field survey, there are some indications that the sampling system may be sensitive to ambient temperature. This is apparently caused by condensation and a degree of evaporation. The exact temperature at which this effect occurs has not yet been clearly defined. It had been thought that the presence of CO_2 in calibrating gas compensated for the analyzer's response to CO_2 in Model 28. Apparently this is not the case. Further study of water sensitivity is also indicated. None of these effects completely accounts for the differences between the field survey results and results obtained by individual members of the Committee for smog studies on other phases of the air pollution study.

To Order Paper No. 11A . . .
on which this article is based, see p. 5.

Tractor Trends —Design, Cost, And Performance

Based on paper by

B. G. RICH
and
W. H. WORTHINGTON
Deere Mfg. Co.

One tractor manufacturer notes the following trends in tractor design, performance, and cost:

1. Tractor horsepower, weight, and drawbar pull are increasing.
2. There is requirement to operate on gasoline, LP gas, and diesel fuels.
3. Tractors are being adapted to a wider range of associated equipment, with greater usage of hydraulic controls, power take-offs, and with increasing demands upon loads, speeds, and work capacity.
4. Items which contribute to comfort, ease of handling, and operator convenience, even though they represent a large part of tractor cost, are well received, and many are indispensible.
5. The increased power requirements, wider use of more complicated hydraulic equipment of greater capacity, independent power take-off, and demand for easier and more comfortable operation, result in higher tractor prices. Also, use of LP gas and diesel engines results in higher prices.
6. Fewer farm tractors are required; as the work capacity and adaptability of individual tractors goes up, the working farm population decreases, and the size of individual farms increases.
7. There is an increasing variety of tractors, and more selectivity by customers, to incorporate in each individual case the items of optional equipment necessary or desired, and eliminate those unnecessary or undesired, according to individual needs.

To Order Paper No. 13B . . .
on which this article is based, see p. 5.

Turbocharged Diesels Still Have Far to Go

Based on paper by

BRUNO LOEFFLER
and
MERRILL C. HORINE
Mack Trucks, Inc.

(Presented before the SAE Southern California Section)

Turbocharging of diesel engines is still in its infancy. Its further progress is beset with many problems; but as study and experience accumulate, their solution seems certain. The principal objective is higher brake mean effective pressure, not at one point on the speed range but throughout the operating zone of speeds and with ever lower specific fuel consumption.

To accomplish these results it will be necessary to have ever closer coordination between engine and turbocharger design. The turbocharger must not be regarded as an accessory, but rather an integral component of engine design. We will never get far on the basis of conversion of normally charged engines to turbocharging. Pinwheels, whether operating centripitally, as in turbines, or centrifugally as in blowers, are essentially efficient only under fixed conditions; whereas the requirement of automotive engines is that they must be efficient through-

out a broad range.

Possibilities of future development are the provision of adjustable nozzle rings, automatically compensating for changing exhaust volume and possibly similarly adjustable diffuser rings on the blower. To improve starting and accelerating performance, some means of changing the compression ratio in operation would be of great value, as well as a mechanical drive for the rotor, acting through an overrunning clutch, for starting, idling, and very light loads.

Problems involved in injection also invite intensive study and experiment. Obviously, if any benefit in the way of increased power is to be gained from supercharging, it is necessary to provide for increased maximum injection volume while still maintaining proper spray patterns at minimum output. This means either larger or a greater number of nozzle orifices or longer duration of injection. The latter seems the more attractive from several standpoints, particularly in modern swirl-type combustion chambers; for with larger or a greater number of orifices, it will be difficult to control the spray of minute quantities of fuel. Certainly, something would seem necessary to prevent overinjection in starting, acceleration, and idling.

To Order Paper No. S53 . . . on which this article is based, see p. 5.

Turbochargers Encounter Oil Film Whirl Vibration

Based on paper by

C. N. FANGMAN

and

J. L. HOFFMAN

Caterpillar Tractor Co.

ONE of the causes of instability in diesel-engine turbochargers operated at high speed is oil film whirl vibrations. They are caused by hydrodynamic forces, and are largely dependent on the masses of the rotating assembly and bearing configurations.

Ample quantities of oil in large clearance, sleeve-type bearings are helpful in supplying some damping action to reduce forced (out-of-balance) vibrations, but they also fulfill the conditions necessary for the existence of these oil film vibrations. Large amplitudes of vibrations can result, making effective sealing of the air and oil difficult.

Oil film whirl vibrations are basically self-excited vibrations existing within the system because of pressure differences developed between opposite sides of a rotating shaft. As the center of the rotating assembly is displaced from the center of the bearing, it becomes in fact a pump. When the pressure differences developed by this pump are great enough to drive the rotor around in its bearing clearances, the phenomena associated with oil film whirl vibrations are detected. The exciting forces, therefore, are the pressure differences developed by the pumping action. Obviously, the magnitude of these forces required to cause oil film whirl are less when the rotating assembly is lightly loaded in addition to being light in mass. As higher rotating speeds are attained, the pump output is greater, hence, it is only logical that oil film whirl phenomena have especially been observed in lightly loaded high-speed rotating machinery.

Types of Oil Film Whirl Phenomena

In a turbocharger system two general types of oil film whirl phenomena can exist. One of which, for the lack of a better word, could be called "cylindrical whirl." Cylindrical whirl occurs when the whirl amplitude measured at one end of the rotating assembly is approximately equal to the bearing clearances. Viewing the assembly from the side, the motion generated by the whirling assembly is a cylinder whose diameter is approximately equal to the bearing clearances.

The second type can be defined as

Vee Design Cuts Size, Lifts Power of Stationary Diesel Engine

Based on paper by

H. M. HIRVO

General Metals Corp.

(Presented before SAE Northern California Section)

THE Enterprise RV-16 stationary diesel with 17-in. bore and 21-in. stroke gives 43% more horsepower per square foot than a comparable 8-cyl inline diesel with 20-in. bore and 25-in. stroke. Its overall height is only 12 ft, 4 in.

Performance characteristics are given in Fig. 1. The lower curve shows that from 65 to 154 psi bmep, which is equivalent to 2250 to 5350 bhp, the specific fuel consumption is below 0.36 lb per bhp-hr. From 78 to 119 psi bmep, or 2750 to 4100 bhp, the fuel consumption is about 0.35 lb per bhp-hr. These figures were obtained from break-in runs of a production engine. Values as low as 0.345 lb per bhp-hr were obtained in laboratory tests.

The middle curve shows exhaust temperature plotted against load. At about 5000 bhp, or 144 psi bmep, the temperature is 850 F. The top curve shows the peak pressure to be 775 psi at 145 psi bmep.

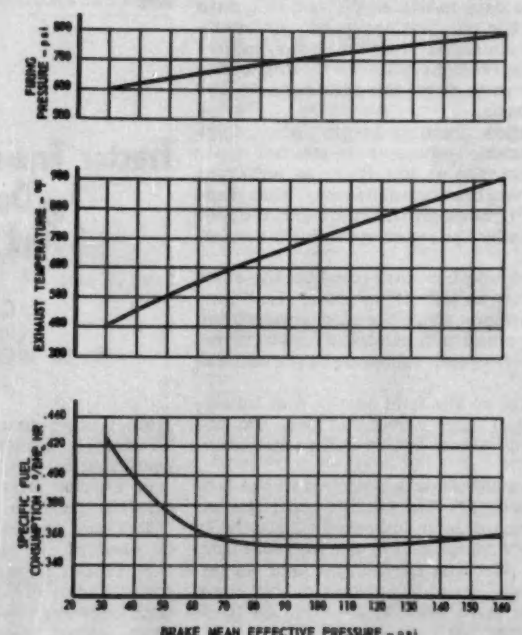


Fig. 1 — Performance characteristics of Enterprise RV-16 diesel stationary powerplant. Engine is so compact it can be shipped assembled.

To Order Paper No. S34 . . . on which this article is based, see p. 5.

"conical whirl." The whirl amplitude measured at one end of the rotating assembly can, in this case, be many times greater than the bearing clearances, depending upon the extent of overhang of the rotating wheels or masses from their bearing supports. The whirl path generated is the result of a rotating assembly whirling in a cocked position within its bearing clearances. When viewed from the side, the whirling of the assembly would generate a cone whose maximum diameter at the end of the shaft not only depends upon specific bearing clearances but the extent of the overhang of the wheels from the bearing supports. Conical whirl is extremely undesirable under these conditions since, in most turbocharger designs, at least in the present stage of development, seals used to keep the air out and the oil in are of necessity located outboard of the bearings. Large seal clearances have to be employed, which make it difficult, if not impossible, to obtain adequate sealing.

Unfortunately, this type of whirl is by far the most prevalent, since it is generally the result of an overhung, 2-mass system having vastly different masses and moments of inertia. The heavy end tends to lag the light end, resulting in the assembly whirling in a cocked position within its bearings. From this standpoint it would be desirable to have the mass and moment of inertia of the turbine wheel and the compressor wheel more nearly equal. From a system response standpoint, considering the temperatures on the hot turbine end and the density of the material that must be used, it is not very easy to obtain such a system. It is evident, therefore, that small bearing clearances would be desirable since the amplitudes of oil film whirl vibrations are a function of the clearances regardless of whether cylindrical or conical type oil film whirl occurs.

The amplitudes of vibrations associated with conical whirl have been observed to increase as the turbocharger speed increases, while the ratio of whirl frequency to the rotational speed decreases. This ratio will vary from a maximum of 0.5 to approximately 0.38. Under these conditions it would be conceivable that collapse of the oil film could result without unbalance present in the system, since the inertia force of the overhung wheel about the bearing centerline increases as it becomes displaced further from the centerline of the bearing at the higher whirl speeds. It is especially logical since the required force to collapse the oil film under these conditions may not be very great, because the rotating assembly is loading only a small portion of the oil film that is possible within the bearing length.

To Order Paper No. 7A . . .
on which this article is based, see p. 5.

Work Sampling—An Aid to Cost Control

Based on secretary's report by

W. L. BREESE

Ryan Aeronautical Co.

WORK sampling provides a simple but relatively inexpensive tool for acquiring information and data upon which management can make sound decisions affecting costs and hence profits.

Work sampling in its simplest form means taking random observations of a group of workers and noting whether they are working or idle. At the end of the day total your "working" and "idle" observations. If you have 80 working observations and 20 idle observations your working time is $\frac{80}{100}$ or 80% and your idle time is $\frac{20}{100}$ or 20%.

This, it is true, is a sample, but based on the theory of probability the sample tends to have the same pattern of distribution as the total from which the sample was taken if: (1) your sample was a random sample, and (2) your sample was adequate or ample in size.

Now since sampling is a form of measurement, it is necessary to accept certain tolerances. A simple formula for determining the number of observations required is:

$$N = \frac{4(1-P)}{S^2P}$$

where:

P = % of activity
S = Standard error of percentage or tolerance
N = Number of observations required

For S a figure of 5% is generally used as acceptable for satisfactory work sampling results.

For 80% activity and 5% standard error:

$$N = \frac{4(1-0.80)}{(0.0025)(0.80)} = \frac{0.80}{0.002} = 400 \text{ observations}$$

If we wish to use work sampling to set a standard, we have one more element to consider and that is "pace rating." Here the observer must note whether the worker is working or idle and then, if the worker is working the observer notes the pace of each worker being observed.

The weighted pace would be determined as follows:

	30 at 70%	= 21.00
	40 at 80%	= 32.00
	30 at 90%	= 27.00
Total	100	80.00

The pace would then be $\frac{80}{100} = 80\%$.

We can then use the following formula to determine the standard time per unit:

$$\text{Standard time per unit} = \frac{(\text{total time})\ (\%\ \text{activity})\ (\%\ \text{pace})}{\text{total units produced}} + \text{allowance}$$

Also serving on the panel which developed the information in this article were: L. K. Pratt, Ryan Aeronautical Co.; M. Creamer, Northrop Aircraft, Inc.; A. Hendricks, General Dynamics Corp.; M. C. O'Connor, Douglas Aircraft Co.; K. J. Mulleda, Lockheed Aircraft Corp.; E. F. Mellinger, Ryan Aeronautical Co.; and D. Darnell, North American Aviation, Inc.

To Order SP No. 321 . . .
on which this article is based, see p. 5.

Future Performance Goals Set for Outboard Engines

Based on talk by

LOWELL E. HAAS

Scott-Atwater Mfg. Co., Inc.

(Presented before SAE Southern California Section)

PERFORMANCE goals for future Scott-Atwater outboard engines are:

- All moving parts must be capable of running 1000 hr at 4200 rpm, or 100 hr at 5000 rpm.
- Powerhead must pass a 200-hr lake test.
- Magneto must function properly for 1000 hr at 4200 rpm with only one point adjustment at the end of 500 hr.
- Plug life, as affected by electrode erosion due to magneto design, shall not be less than 50 hr.
- Carburetors should operate a minimum of 1000 hr with no maintenance.
- Fuel pump must operate without maintenance for a minimum of 1000 hr at 4200 rpm.
- Intake silencers must operate satisfactorily for 1000 hr at any speed up to 5000 rpm, with no failures from fatigue.
- Electric choke must function satisfactorily for 200,000 cycles with no maintenance.
- Electric starter motor, mounting brackets, starter solenoid, and ring gear must operate satisfactorily and with no maintenance for 30,000 2-sec starts.
- Automatic Recoil Starter — All component parts must pass 30,000-cycle test on starter cycler.
- Synchronous Control Mechanism — Twist grip and related mechanism must pass 1000-hr endurance test with no failure, loosening, or excessive wear of any functional parts. Mechanism must pass 200-hr lake test and static

test that consists of applying 150-in.-lb. torsion to the twist grip handle.

- Shrouds must pass both 1000-hr endurance run and 200-hr lake test without any failures.
- Boat brackets must pass 1000-hr endurance run in addition to the 200-hr lake test and static test for breaking strength. Static breakage strength of boat brackets, regardless of size, must be equal to or greater than 300 in.-lb. torque applied to the clamp screw.
- Pivot tube must pass 1000-hr endurance run as well as 200-hr lake test.
- Reverse lock mechanisms must pass both 1000-hr endurance and 200-hr lake runs. Reverse lock will also be tested for holding ability by shifting into reverse at excessively high speeds.
- Lower Motor Casing — Castings must pass 1000-hr endurance test without any failures.
- Water pumps must pass 1000-hr endurance test running and pumping at full capacity. Pumps will also be required to operate 50 hr in silty or abrasive water and pass a 200-hr lake test.
- Shift mechanism will be required to pass a 20,000-cycle shift run.
- Lower unit will be required to pass 1000-hr endurance run at 4200 rpm with no major failure. Lower unit must pass 200-hr lake run that includes impact tests.
- Prop shock absorber hubs must be able to withstand "oak plant" tests.

Briefs of SAE PAPERS

Continued from page 6

MEYER, R. G. GOLDTHWAIT. Paper No. 258 presented Nov. 1957, 18 p. Study by Gulf Research & Development Co., to determine effects of both factors on road performance at present approximate research octane level of premium gasolines; test fuels, cars, and test procedure; effect of sensitivity and hydrocarbon type and correlations of road ratings at max obtainable throttle opening; part throttle investigations.

Road Rating of 100+O. N. Fuels in High Compression Ratio Cars, E. F. MARSHALL, C. S. GILBERT, Jr. Paper No. 259 presented Nov. 1957, 13 p. To obtain octane ratings above 100 octane numbers, three different types of "future design" experimental engines at nominal 12:1 compression ratio level were used in test program carried out by Sun Oil Co. Research Dept; data on individual fuels used and road ratings; rating techniques used; correlations between laboratory and road ratings; effects of fuel composition and fuel sensitivity; rating problems encountered.

Laboratory Qualities as Predictors of Road Octane Number, I. A. CAPUTO, H. J. SEWELL, H. A. TOULMIN. Paper No. 260 presented Nov. 1957, 10 p. Using road and laboratory antiknock data obtained on 91 commercial premium gasolines in five 1957 test cars and 16 prototype fuels in three high compression ratio cars, equations are developed which permit calculation of road octane number from knowledge of various combinations of laboratory qualities; relative importance of each laboratory variable in enhancing prediction equation is assessed.

"Laboratory Octane Ratings — What Do They Mean?" R. B. FELL, H. F. HOSTETLER. Paper No. 263 presented Nov. 1957, 12 p. Results of several anti-knock studies to determine practical application of laboratory to road octane rating relationships, and effect of vehicles, and operating conditions on these relationships; results show that there is valid correlation between laboratory and road octane ratings; equations developed to predict road performance from laboratory octane ratings.

Relationship Between Time, End-Gas Pressure, Temperature, and Knock, J. H. MacPHERSON, J. A. BERT, K. L. KIPP. Paper No. 3A presented Jan. 1958, 14 p. Critical review of weaknesses of past empirical correlations relating conventional engine operating conditions to occurrence of knock; test program conducted in Merz 17.6 cu in. displacement engine; methods for calculating end-gas conditions; analysis of test data; it is shown that time factor must be considered to improve correlations.

Effect of Fuel Injection on Knocking Behavior, A. E. FELT, D. L. LENANE, K. W. THURSTON. Paper No. 3B presented Jan. 1958, 8 p. Validity of claims of reduced octane number requirement and improved fuel economy with fuel injection systems investigated by Ethyl Research Laboratories; test program involved comparisons of fuel injection and carburetion systems; results show that fuel injection improves tetraethyl lead effectiveness over wide speed range.

Measurement of Gas Temperature in Engine by Velocity of Sound Method, J. C. LIVENGOOD, C. F. TAYLOR, P. C. WU. Paper No. 3C presented Jan. 1958, 28 p. Report on work at Mass Inst Technology concerned with process occurring in gases within cylinder; application of pulse method and equipment used; typical results; effect of engine variables and end-gas temperatures; temperature measurements to evaluate extent and character of heat losses during several phases of cycle, and losses due to noninstantaneous combustion.

Field Survey of Exhaust Gas Composition, G. WAY, W. S. FAGLEY. Paper No. 11A presented Jan. 1958, 34 p.

Continued on page 114

Diesel Performance To Advance Steadily

Based on paper by

DR. HERBERT H. HAAS

Continental Aviation & Engineering Corp.

(Presented before SAE Metropolitan Section)

THE high-performance diesel engine will maintain its place as a highly efficient prime mover at least in the decade to come. Here are some of the advances to be anticipated:

1. Bmep up to 250 psi through supercharging, preferably by exhaust turbocharger. The trend is toward still higher bmep and 300–400 bmep is not beyond reach.
2. High breathing capacity achieved by multiple of angle valve arrangements permitting piston speeds up to 2400 fpm. Further increase in piston speed is likely to be moderate because of inherent friction, inertia, and breathing problems. 2600-fpm piston speed and an absolute speed of 3000 rpm may be the limit for engines of 600–1000-hp size.
3. Ultimate rigidity and compactness of crankcase and crankshaft permitting combustion pressures up to 2000 psi.
4. Extensive use of aluminum and high-strength alloy steels resulting in a specific weight of 4–5 lb per hp. The ultimate rigidity of the engine structure must be high to withstand the pressures and loads in future engines, thus limiting the possible weight reduction for a given engine size.
5. A major breakthrough is more likely with fuel injection than with combustion. Systems like accumulator and pilot injection may deserve more consideration if a wide speed and load range is required. Combustion development toward controlled turbulence and vaporization rate may ease the task of the fuel-injection system at high speeds. However, satisfactory heat dissipation will set limits in this direction. Moderate improvement of turbocharger efficiency and blade materials can be expected, and will support essentially the trend for high bmep.

To Order Paper No. S55 . . . on which this article is based, see p. 5.

★ SAE SUMMER MEETING

JUNE 8-13

CHALFONTE-HADDON HALL

ATLANTIC CITY, N. J.

★MONDAY

steel spring suspensions
power control systems
atomic energy
symbiosis

★TUESDAY

chassis dynamometers
truck noise
industrial research
lubricant performance
small engines
1958 thunderbird

★WEDNESDAY

new materials
high compression ratio and engine noise
locomotive diesel maintenance
safety

★THURSDAY

diesel supercharger
safer and more comfortable seats
rating the diesel
aluminum for tomorrow's cars
vehicle-road relationships
station wagon living

★FRIDAY

aluminum engines

GASLIGHT GAYETIES

WED., JUNE 11, 7:00 P.M.

DURING A COLD SNAP

of −5 F in Detroit, more than 50,000 motorists — or 15% of those requiring the use of their cars — could not start their vehicles without help. One stranded was GMC Research Staff's Theodore W. Selby, a speaker at the first joint Automotive Lubrication Conference of the **CHICAGO SECTIONS** of SAE and ASLE (March 11). Selby's presentation was, appropriately enough, on low-temperature behavior of motor oils. . . .

At the same meeting, Outboard Marine's W. C. Conover said that **87.9% of all U. S. power boats have outboard motors.** In 1957, these boats consumed 259 million gallons of gasoline and 13 million gallons of lubricating oil. . . .

Contribution from three Standard of Indiana researchers: **"Base oils add the largest increment** to engine octane-requirement increase, viscosity-index improvers add less, and detergents and inhibitors add the least." The researchers were M. L. Kilinowski, L. D. LaCroix, and R. A. Nejdl.

In Minneapolis (**TWIN CITY SECTION**, March 12) the joint groups heard about the current status of gear lubrication from Monsanto's T. P. Sands.

• • •

To break the glaze, or not to break the glaze, that is the question. But the answers are varied — most piston ring manufacturers recommend that glaze breaking is not necessary — however rings don't seat quickly against a smooth, glazed cylinder surface. A deglazed, rough cross-hatched surface is best for quick seating — but improper cleaning procedures after deglazing cause premature ring and engine failure.

NEW ENGLAND SECTION Speaker J. O. Lutz (Wilkening Mfg. Co.) also stated that, in the final analysis, "If properly done, deglazing the cylinder wall assures the best opportunity for quick ring seating and immediate satisfactory engine performance."

• • •

Via the St. Lawrence River Seaway Project, the distance from Southampton, England to Buffalo, New York, will be approximately equal to the distance from Southampton to NYC . . . and in the former case, goods will reach considerably farther inland before transshipment is necessary. (Ralph H. Gallinger, chief of Construction Division, U. S. Army Corps of Engineers at **BUFFALO SECTION**, March 19.) In just two months, the Seaway's main power and water phases will be ready for vessels of up to 14 ft drafts.

Rambling . . . THROUGH THE

GE's H. M. Weber, Jr. told **MOHAWK-HUDSON SECTION** members that the first stage engine for the Vanguard lifts the vehicle to a height of about 40 miles and accelerates it to a velocity of 3,000 mph; the second stage's mission is to raise the vehicle to the satellite launch altitude, 300 miles, and accelerate it to a velocity of 9,000 mph. The final increment is supplied by a solid rocket engine. (March 11).

• • •

Without a hump in the floor, automobile designers will have more imaginative freedom and the public can look forward to more attractive and roomy car interiors. One way to attain this "hump-less auto," GMC Research Staff's W. H. Percival told **MID-CONTINENT SECTION,** is with a free-piston powerplant. (March 7).

• • •

Top driving honors were captured by Gordon Spenser in SAE Intercollegiate Safety-Economy Run, sponsored by **NORTHERN CALIFORNIA SECTION,** February 26. As part of the Section's Student Meeting, 18 students and 5 California colleges and universities participated in a 77.7 mile course through Alameda and Contra Costa counties.

Spenser, SAE Enrolled Student at University of California, achieved the **average of 64.9 ton-miles per gallon** of gasoline and 25.06 actual miles per gallon. Sweepsteak Trophy for the best school average went to California Polytechnic College with a score of 53.1 ton-miles per gallon. (In each case, 0.1 ton-mile per gallon was deducted for any safety violation.)

Second place individual winner was Fred Strange of U. of C. with 63.2 ton-miles and 25.6 actual miles per gallon of gasoline. Tied for third place were Jim Locke of California Polytechnic, and Henry Schade, Jr. of U. of C., with 58.2 ton-miles per gallon. **Locke and Schade also shared top honors** in actual miles per gallon with a mark of 27.7.

Participating schools, in addition to U. of C. and California Polytechnic, were Stanford University, College of San Mateo, and San Jose State College.

The safety-economy run was followed by a tour of the Engineering Department of U. of C., after which Professor A. L. London of Stanford University gave a progress report on the compound piston-and-turbine family of engines.

Congratulating Winner Spenser are, left to right, Frank McCord, General Petroleum Corp.; Spenser; Ralph H. K. Cramer, Section vice-chairman of Student Activities and coordinator of the Run; and Ron Frankis, California State Automobile Association.

• • •

Pre-meeting discussion at **CLEVELAND SECTION'S** March 10 meeting included, left to right, speakers M. J. Tauschek, J. M. Cherrie, and A. K. Hannum, all of Thompson Products, Inc.

SECTIONS

Keen competition sparks the eight teams in **CLEVELAND SECTION'S** Company Representative Plan . . . with quality rather than quantity stressed in new member applications.

Increased incentive to exceed application quotas and surpass other teams comes monthly, when team ratings are printed in the Section's "Junior Journal."

The 42 member committee is divided with each team responsible for 25 companies, usually a few large concerns and the majority smaller companies.

• • •

SAE's Far-Eastern "ambassadors" currently are the **MILWAUKEE SECTION Lecture Series papers** — being translated for use by Japanese-speaking engineers.

SAE member Usaburo Furubayski has requested permission to translate the series for his use as chief, aviation engine department, Fuji Motors Co., Toyoko . . . and for the use of other engineers in Japan.

Third meeting of the **MILWAUKEE SECTION** Lecture Series was attended by SAE President W. K. Creson, and featured a paper by co-authors E. S. Dahl of Marvel-Schebler Products Division, Borg-Warner Corp., and W. E. Meyer, professor of mechanical engineering, Pennsylvania State University. Subject of the paper was "Application of Fuel Injection to Spark Ignition Engines."

Left to right: W. E. Meyer; W. K. Creson; E. S. Dahl; and E. H. Panthofer, Milwaukee Section chairman.

By 1965, Russian industrial equipment and techniques can be expected to be comparable to those in the U. S. — and by 1970 possibly in a superior position — Ford's Nevin L. Bean told members of the **MID-MICHIGAN SECTION** in March.

Principals at the meeting were, left to right, Karl Schwartzwalder, Section Program Committee chairman; Speaker Nevin Bean; SAE President W. K. Creson; Section Chairman Philip B. Zeigler; and N. R. O'Hara, Section meeting chairman.

Can a ballistic missile deliver an atomic bomb more effectively or more accurately than a B-52? . . . asked D. M. Heller of Bendix Missile Section at the **South Bend Division, CHICAGO SECTION.** It all depends, he answered, on:

- tactical usefulness of all areas of weapon progress; and
- economic balance of increasing weapon system costs . . .

Warning — Heller said: too much enthusiasm over one particular weapon can be as dangerous as putting all your eggs in one basket. . . .

Speaker Heller, right, demonstratively discusses his paper with Commander F. M. Sanger, Jr., left, and Ray A. Trapp of Bendix Products Division.

Past-Chairman's Night at **SOUTHERN NEW ENGLAND SECTION** featured J. C. Hamaker, Jr. of Vanadium Alloys Steel Co. and his paper on "High Strength Steels." Past chairmen attending the meeting included, left to right, Claude O. Broders; Kenneth F. Thomas; Hans Hogeman; Roland K. Blakeslee (present chairman); Herbert W. Best; Richard C. Molloy; Chas. W. Phelps; David E. Waite; and Lester C. Lichty.

March meeting of the **ATLANTA SECTION** was especially eventful . . . it played host to SAE President W. K. Creson who presented a charter to a newly installed Student Branch at Georgia Institute of Technology.

Participants in the ceremony were, l to r, L. C. Malone, Section chairman; Bill Wild; Bruce Moore, Student Branch chairman; and W. K. Creson.

1958 Thunderbird was the topic of the March 11 meeting of the **DAYTON SECTION.** L to r: Harlan Fengler, Aircraft Engine Division, Ford; Curtis P. Kelley, Section publicity chairman; F. J. Hooven, speaker from Ford; J. H. Overwein, Section chairman.

"The Middle East — Its Oil, Its People, and Its Influence," was covered March 10 at the **SOUTHERN CALIFORNIA SECTION** by Speaker Captain John C. Martin, U. S. Navy. Martin, center, and Commander Weiler, U. S. Navy, right, are greeted by Section Fuels and Lubricants Vice-Chairman J. F. Snider, left.

Coffee Speaker was Roger M. Mahey, who discussed his round-the-world trip in a 1958 Ford.

Rambling . . .

THROUGH THE

Continental Motors' approach to fuel injection in business aircraft was discussed by their Quality Aircraft Division's chief engineer — William A. Wiseman — at **WESTERN MICHIGAN SECTION** in March.

Left to right: Elias W. Scheibe, senior engineer, GMC Diesel Equipment Division; L. W. Kibbey, applications engineer, Sealed Power Corp.; Speaker Wiseman; W. C. Chaffee, director of engineering, Bennett Pump Division, John Wood Co.; W. A. MacLaurin, industrial representative, Shell Oil Co.

• • •

Greeting Speaker Dave Buell of Chrysler's missile plant is Richard J. McHugh, faculty advisor of **UNIVERSITY OF DETROIT STUDENT BRANCH** . . . Buell spoke on "Guided Missile Problems" to the Enrolled Students at their February meeting. Left to right: Buell; McHugh; John A. Finnegan, Student Branch chairman; Eugene Barc, Branch secretary-treasurer; and William Haggerty, Student Branch vice-chairman.

SECTIONS

Governing Board members of the **MID-CONTINENT SECTION** for the 1957–58 season, front row left to right: Cecil L. Cotton, arrangements; W. L. Thompson, vice-chairman; Harold T. Quigg, vice-chairman, Fuels and Lubricants; W. F. Ford, Section representative; F. E. DeVore, Section chairman; Enos W. Cave, placement; and Idan E. Flaa, secretary.

Rear row, left to right: Warren A. Brown vice-chairman, Transportation and Maintenance; Wade M. Johnson, Section delegate; W. W. Schafer, program; J. L. McGinniss, reception; Leonard W. Okon, student; Howe Carey, publicity and field editor.

SAE SECTION MEETINGS

ALBERTA

May 16 . . . Ladies Night. Al-San Club, Alberta. Dinner 7:30 p.m. Meeting 8:30 p.m. Special Guest: SAE President W. K. Creson.

BALTIMORE

June 21 . . . Dinner-Dance. Gridiron Club, 6700 Block Loch Raven Blvd.

BRITISH COLUMBIA

May 26 . . . Annual meeting. Members only. Film. Hotel Georgia.

CENTRAL ILLINOIS

May 26 . . . Marion 70 cu. yd. Shovel. Pere Marquette Hotel, Peoria. Dinner 6:30 p.m. Meeting 7:45 p.m.

CHICAGO

May 23 . . . Ladies Night. Cocktails, dinner, entertainment, dancing. South Shore Country Club. Time 7:30.

CINCINNATI

May 26 . . . Ollie James, columnist, "The Cincinnati Enquirer." "Have a Sense of Humor." Engineering Society Headquarters. Dinner 7:00 p.m. Meeting 8:00 p.m.

CLEVELAND

June 5 . . . Annual golf outing. Elyria Country Club.

COLORADO GROUP

May 15 . . . Fuels and Lubricants Activity Meeting.

INDIANA

May 15 . . . Harlan Fengler, chief steward, Indianapolis "500" Race. "The 500 Mile Race." Indianapolis Athletic Club. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Guests: Tony Hulman, owner "500" Race Track; Tom Binford, president US Automobile Club; Duane Carter, director of competition, USAC.

KANSAS CITY

May 15 . . . Field Trip. Mid-Continent International Airport. TWA Overhaul Base. Dinner 7:00 p.m.; meeting 8:00 p.m.

METROPOLITAN

May 15 . . . H. S. Kelly, Socony Mobil Oil Co. "What Do the Gas Economy Runs Prove?" Roger Smith Hotel, Lexington Ave. & 47th St., New York City. Luncheon 12 Noon. $3.00 including tip.

May 23 . . . Spring Dinner-Dance. Sleepy Hollow Country Club, Scarborough-on-Hudson, New York. Special Feature: 12 Noon, golf, tennis, riding, trap, cards, softball and horseshoe pitching. Sponsored cocktail hour 6:45 p.m. Dinner-Dance 7:45 p.m. Prizes. $7.50 per person.

May 27 . . . Fuels & Lubricants Activity Meeting. C. R. Noll, Gulf Oil Corp. "New Gear Lubes." Henry Hudson Hotel, 57th St. & 9th Ave., New York City. Meeting 7:45 p.m.

NEW ENGLAND

June 2 . . . Annual Outing at Woodland Country Club, Newton, Mass.

NORTHERN CALIFORNIA

May 28 . . . Field trip to Hamilton Field, Marin County. Special Guest: SAE President W. K. Creson.

NORTHWEST

May 23 . . . President's Night. SAE President W. K. Creson will be the guest of honor. New Yorker Cafe, Tacoma. Dinner 7:30 p.m. Dancing.

OREGON

May 26 . . . SAE President W. K. Creson. "Steering of Modern Automotive Vehicles."

PITTSBURGH

May 22 . . . Annual Pilgrimage to Oil City. Afternoon golf. Speaker will be a representative of the National Automobile Dealers Association. Wanango Country Club, Oil City. Dinner 6:30 p.m. Meeting 8:00 p.m.

ST. LOUIS

May 13 . . . Larry Burgess, assistant chief engineer, highway, Mack Truck Co., Inc. "Bulldog Convoy in the Arctic." Congress Hotel. Dinner 7:00 p.m. Meeting 8:00 p.m.

SOUTHERN CALIFORNIA

May 19 . . . Ross F. Miller, chief engineer, Northrop Aircraft, Inc. "A Systems Approach to Interplanetary Navigation." Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles, Calif. Dinner 6:30.

SPOKANE-INTERMOUNTAIN

May 21 . . . Student Meeting, Washington State College, Student Union Bldg., Pullman, Wash. Guest Speaker: SAE President W. K. Creson, "Tomorrow's Engineer."

WESTERN MICHIGAN

June 7 . . . Ladies Night. Dinner-Dance. Place: Prospect Point.

WILLIAMSPORT

May 29 . . . Ladies Night. Williamsport Country Club. Cocktails 6:00 p.m. Dinner 6:30 p.m.

Continued from page 108

Report of CFR Group on Composition of Exhaust Gases describes operations and results of field survey conducted in Los Angeles from Nov. 5–Dec. 7, 1956; purpose of test was to measure exhaust emissions from group of cars during operating conditions encountered in metropolitan driving; instrumentation and test equipment; data handling and procedures; presentation of results; tables; graphs.

Application of Continuous Infrared Instruments to Analysis of Exhaust Gas, B. M. STURGIS, W. F. BILLER, J. W. BOZEK, S. B. SMITH. Paper No. 11B presented Jan. 1958, 20 p. Progress report on successful use of two analyzers to study effect of engine variables on exhaust gas composition; description of Model 15A Liston-Becker Infrared Analyzer applicable to analysis of hydrocarbon component of exhaust gases, and Model 28 Liston-Becker Exhaust Gas Analyzer which is 3-channel instrument designed to analyze exhaust gas simultaneously for hydrocarbons, carbon monoxide, and carbon dioxide.

Application of Gas Chromatography to Analysis of Exhaust Gas, R. W. HURN, K. J. HUGHES, J. O. CHASE. Paper No. 11C presented Jan. 1958, 13 p, appendix 17 p. Report of accomplishments by Bartlesville Station, Bureau of Mines during 18-mo project to develop method for analyzing hydrocarbon content of exhaust gas using gas liquid partition chromatographic techniques; test program; exhaust gas sampling and transfer; obtaining chromatograph; recovery of fractions from chromatograph; recommendations. Apparatus and performance evaluations described in appendix.

Passenger Car Trends Affecting Fuels and Lubricants, E. M. JOHNSON, C. W. MORTENSEN. Paper No. 12A presented Jan. 1958, 24 p. Design and performance trends of automobiles, with emphasis on recent changes; resulting modification in fuel and lubricant requirements; anti-knock performance, surface ignition and vapor lock tendency; increased severity of crankcase motor oil requirements in connection with valve train problems; transmission fluids; trends in lubricant requirements with regard to rear axles, chassis components and accessories.

Diesel Lubes — Series What? E. M. JOHNSON, H. V. LOWTHER. Paper No. S60 presented Feb. 1958, (Metropolitan Meeting) 19 p. Current requirements and specifications of automotive diesel engine oils are reviewed with reference to U. S. Army specification Mil-L-2104A, Mil-L-9000D (Navy), and Caterpillar Tractor Co.'s Series 2 and 3; performance of lubricants and role of base stock and chemical additives in handling contaminants and debris which may cause excessive deposits and wear; future trends.

Carburetor Evaporation Losses, J. T. WENTWORTH. Paper No. 12B presented Jan. 1958, 12 p. Study of measurement of fuel lost through external float bowl vents of some current carburetors; test results from five cars presented and correlated with carburetor temperature, fuel volatility, and vent design; how results are related to air pollution, idling performance and fuel economy.

GROUND VEHICLES

Dynamometer Testing in Engine Service Shops, G. R. MACKEY. Paper No. S27 presented Nov. 1957 (Spokane-Intermountain Sec.) 14 p. Dynamometer test program for dealers and distributors, devised by Clayton Manufacturing Co., El Monte, Calif., for Service departments to promote better service conditions; typical service operation is analyzed to show improvements that can be expected in shop; details of program and benefits to be obtained which will eliminate many serious weaknesses in engine service.

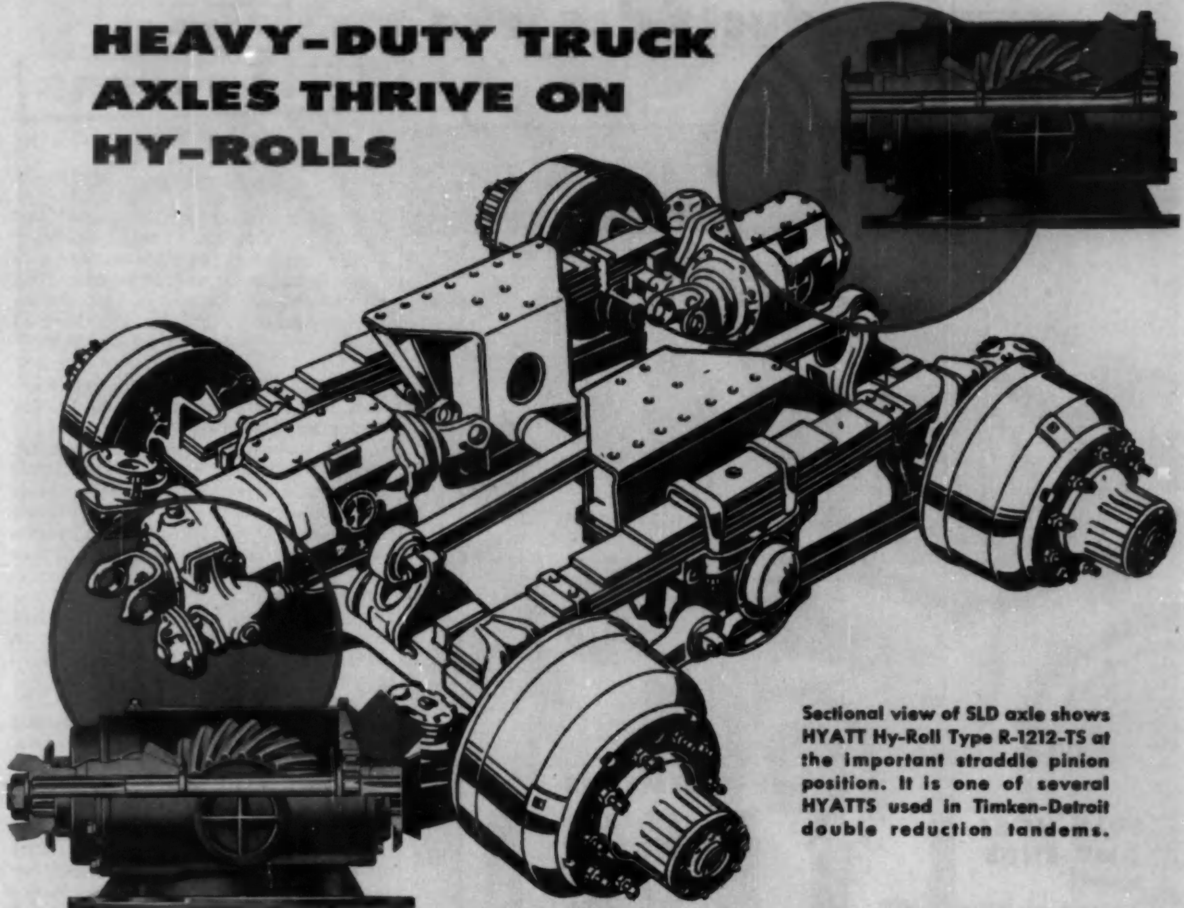
Automotive Design Trends, L. M. FORBUSH. Paper No. S26 presented Oct. 1957 (Mohawk-Hudson Sec.) 5 p. At General Motors, Engineering Staff for long range development work consists of four groups, i.e.: Vehicle, Structure and Suspension, Transmission, and Power Development Group; examples of work done on new body materials, manufacturing economics of materials, GM fuel injection system, special automatic transmissions in military tanks and ordnance vehicles, etc; functions of Automotive Ordnance Group.

Dragnet for Defects — Proving Ground Operation, H. M. BEVANS. Paper No. S47 presented Feb. 1958, (Metropolitan Sec.) 8 p. Feature of Chrysler's 4000-acre testing area near Chelsea, Mich., which provides facilities for endurance operation simulating as many conditions as possible; these range from smooth roads of blacktop and concrete to very rough, broken surfaces and gravel including various grades and curves; testing techniques applied to various components.

Daimler-Benz Swing Axles, H. SCHERENBURG, R. OHLENHHAUT, J. MULLER. Paper No. 10B presented Jan. 1958, 20 p. Theoretical analysis of behavior during curves considers rigid axle, normal jointed and single joint swing axles, and for comparison de

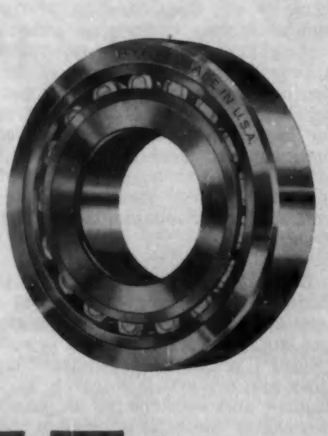
Continued on page 116

HEAVY-DUTY TRUCK AXLES THRIVE ON HY-ROLLS



Sectional view of SLD axle shows HYATT Hy-Roll Type R-1212-TS at the important straddle pinion position. It is one of several HYATTS used in Timken-Detroit double reduction tandems.

TIMKEN-DETROIT SPECIFIES HYATT HY-ROLL BEARINGS FOR SLD, SLDD TANDEM AXLES



These rugged Timken-Detroit top mounted tandems, with straight line drive through double reduction gears, are earning a reputation for dependability and parts interchangeability which keeps downtime and maintenance costs very low.

Typical of the top-quality components that go into these axles are HYATT cylindrical roller bearings, chosen for their ability to carry extremely heavy radial loads without restricting lateral movement, and their ease of assembly and disassembly. Timken-Detroit Division of Rockwell Spring and Axle Company, like other leaders in the industry, depends on HYATT engineering and production know-how for the *best* in bearings. So can you! Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey; Detroit; Chicago; Pittsburgh; Oakland, California.

THESE LEADING COMPONENT MANUFACTURERS ALL USE HYATT BEARINGS:

★ CLARK EQUIPMENT COMPANY (transmissions and axles)
★ DANA CORPORATION (Spicer transmissions)
★ EATON MANUFACTURING COMPANY (axles)
★ FULLER MANUFACTURING COMPANY (transmissions)
★ ROCKWELL SPRING AND AXLE COMPANY (Timken-Detroit axles)

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908—1958
GM
FORWARD FROM FIFTY

HYATT *HY-ROLL BEARINGS* FOR CARS AND TRUCKS

Briefs of SAE PAPERS (continued)

Continued from page 114

Dion axle, and DB series single joint swing axle, type 220 A; equations show that wheel load difference on rear axle depends on position of center of gravity above road surface and of instantaneous center of rear axle; structure of various axles and their suspensions.

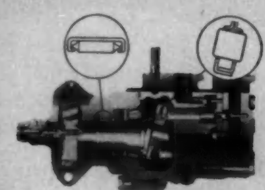
Citroen DS-19: Its Design, Construction and Performance, J. R. BOND. Paper No. 10A presented Jan. 1958, 16 p. Front wheel drive arrangement, combined with close-coupled power unit assembly, is primarily responsible for excellent seating layout; tabulation of weight distribution which varies with passenger load; 4-cyl engine has 3.07×3.94 in. bore and stroke, and compression ratio 7.50; independent suspension used at both ends; central hydraulic system consists of single-high pressure pump and accumulator; performance.

Matching Car Structure to Stylist's Concept, P. KYROPOULOS. Paper No. 4B presented Jan. 1958, 19 p. Aspects of morphology of automobile; structure, meaning body and chassis or their combination, discussed; possible variations of body and chassis and their combination into "integral" construction; it is pointed out that car structures must be designed for limited deflection, and that under these conditions, use of light alloys does not necessarily result in weight saving.

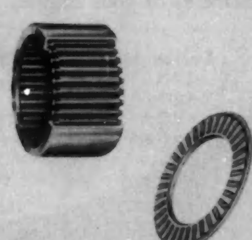
Style is More Than Skin Deep, R. F. McLEAN. Paper No. 4A presented Jan. 1958, 16 p. Consideration of fundamental factors underlying automobile styling; three basic elements of systems approach are task of car, its performance, and its cost; layout of passenger compartment; provision of space for mechanical components; arrangement of these elements in exterior form efficient from aerodynamic and pleasing from esthetic viewpoint is considered as most fundamental problem in design of car.

Engineering Edsel, N. L. BLUME. Paper No. S30 presented Oct. 1957 (Detroit Sec.) 23 p. Account of engineering story of Ford's medium priced car "Edsel"; preliminary studies included sales and marketing research, package studies and establishing of basic dimensional limitations; design details such as steering wheel location; instrument and panel motion study; speed warning light and power steering operation; 3-stage cooling system; dual range transmission; air suspension; specifications of E-400 engine in Ranger-Pacer and E-475 in Corsair-

Continued on page 118



Cross section shows how a Torrington Needle Bearing and a Needle Thrust Bearing handle high radial and thrust loads in minimum space in Ford's hydraulic piston pump.



Briefs of SAE PAPERS (continued)

Continued from page 116

Citation series; tests.

Practical Methods for Car Noise Reduction, R. H. BOLLINGER, H. N. McGREGOR. Paper No. 2B presented Jan. 1958, 10 p. Principles of noise control applied to Ford cars; period noise distinguished on basis of its frequency, amplitude and whether or not it is torque sensitive; sources of background noise are wind, road, engine machinery, fan and driveline bearing noise; laboratory tests and methods used to determine service performance by measuring car noise under actual driving conditions.

Air Coil Spring — New Factor in Rambler Suspension, W. S. BERRY. Paper No. 9B presented Jan. 1958, 12 p. System using airsprings at rear wheels only is based upon analysis of effect of extreme load on weight distribution; Goodyear Rolling Lobe Air Spring, made with neoprene, is designed to go inside rear coil spring, thus paralleling characteristics of air spring with steel coil spring; arrangement and principal function of single leveling valve; dynamic testing machine and testing of rolling lobes; curves.

Oldsmobile New-Matic Ride, R. W. PERKINS. Paper No. 9E presented Jan. 1958, 10 p. New-Matic Ride chassis includes in addition to new frame following components in suspension system: 4-link rear suspension; diaphragm type air springs, height control valves, air compressor, oil and moisture separator, high and low pressure tank, pressure regulator and elevator valve unit and copper air lines throughout; details of components; leak testing and inspection procedure; schematic diagram; load deflection curve.

1958 Chevrolet Level Air Suspension, K. H. HANSEN, J. F. BERTSCH, R. E. DENZER. Paper No. 9D presented Jan. 1958, 10 p. To realize lowest cost to customer, full coil suspension was adopted with air spring assembly having same shape and fastening as conventional springs; details of four air spring assemblies; integral with each of three of units is leveling valve which automatically controls vehicle height at all times; two leveling valves used in front, and single valve in left rear; air distribution; compressor; leveling operation.

Ford Approach to Air Suspension, C. F. O'SHEA. Paper No. 9C presented Jan. 1958, 14 p. System is composite of number of systems studied and consists essentially of air supply system, control system, air springs, and suspension structural components; front air spring unit has four basic parts: rubber diaphragm, support sleeve, piston, and upper seat and air pipe assembly; details of rear unit; diagrams and spring rate curves.

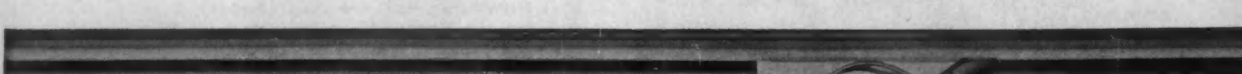
Buick Air-Poise Suspension, F. McFARLAND, G. PECKHAM, E. DIETRICH. Paper No. 9A presented Jan. 1958, 10 p. Outline of General Arrangement and Elements; construction of airsprings embodies diaphragm of 2-ply nylon cord design, rubber-coated inside and outside, which fits into outer rim of metal container; details of control system; advantages.

New Commercial Vehicle Concepts Possible with Air Suspension, D. J. LaBELLE. Paper No. 241 presented Nov. 1957, 11 p. Attempt made to develop new concept of heavy-duty highway tractor by taking advantage of benefits air suspension offers; its influence on principal components such as: tires, wheels and hubs, axle housings, frame, miscellaneous brackets, and cab and sheet metal; use of such materials as aluminum, magnesium and fiberglass-reinforced plastics; stress comparison curve between leaf and air spring.

Continued on page 123

Albee Rolligon covers world's roughest

Six individually powered, high-traction pneumatic rollers carry the Albee Rolligon most anywhere, imposing a ground load of only 5 psi at 21,000 lbs. G.V.W. Designed and built for dependable, off-the-road operation by Albee Rolligon Co. of Monterey, Calif., the ARC uses 54 feet of leakproof Bundyweld for vital fuel and hydraulic lines. And its powerful V-8 engine uses additional lengths of dependable Bundyweld for fuel and oil lines.



BUNDYWELD IS DOUBLE-WALLED FROM A SINGLE STRIP

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

←

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

Briefs of SAE PAPERS

Continued from page 118

Simulation of Free-Piston Engine with Digital Computer, D. R. OLSON. Paper No. 5A presented Jan. 1958, 21 p. General analysis of free piston engine process which would realistically "simulate" operating engine is made in terms of variables which allows basic engine size and configuration to be selected and operating conditions for hypothesized engine to be arbitrarily fixed; numerical description of performance that may be expected; comparison of computed results with engine test results.

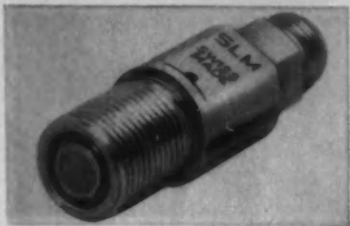
Diesel Cylinder Heat Transfer Design Criteria, D. H. BROWN. Paper No. 249 presented Nov. 1957, 14 p. In thermodynamic analysis of engine design, such as Orion engine, gross cylinder heat loss represents penalty to engine efficiency and output; method by G. EICHELBERG of analytically simulating engine by computation of heat transfer and cylinder temperatures; design criteria derived appear to limit lubricated cylinder wall temperature to less than 500 F; other design criteria.

Loop Scavenging vs. Through Scavenging of Two-Cycle Engines, C. F. TAYLOR, A. R. ROGOWSKI, A. L. HAGEN, J. D. KOPPERNAES. Paper No. 247 presented Nov. 1957, 26 p. Purpose of investigation, carried out at Sloan Laboratories for Aircraft & Automotive Engines, was to compare two methods of scavenging under conditions which would measure their relative merits objectively; methods of evaluation; test equipment and procedure; test results and comparison of engines; limitations of tests; future work.

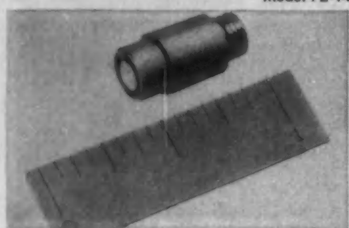
P&H Uniflow-Scavenged Two-Stroke Diesel Engine, M. W. PAQUETTE. Paper No. 246 presented Nov. 1957, 11 p. Design features of line which includes 2, 3, 4, and 6-cyl models, originally built as power source for its own products by Harnischfeger Corp., builders of power shovels, cranes and other heavy equipment: crankcase is cast in high tensile aluminum alloy 356-T71; other major engine components are also of aluminum alloys; reasons for selecting aluminum; details of scavenging system; engine performance and life.

17 Inch Bore V-16 Diesel, H. M. HIRVO. Paper No. S34 presented Oct. 1957, (N. Calif. Sec.) 13 p. General Motors Corp. design philosophy in developing 17-in. bore, 21-in. stroke V-12

Continued on page 124



Model PZ-14



Model PZ-6

Kistler Gages Measure Engine Knock and Detonation Pressures

Quantitative measurements of pre-ignition, detonation, and other abnormal combustion pressures can now be made under the most severe engine operating conditions with the new Kistler SLM Electronic Pressure Gage. Designed to measure either pressure or pressure rate *directly*, the one basic Quartz Gage (Model PZ-14) also indicates compression, peak firing, manifold and fuel injection pressures.

Unlike the familiar mechanical-type pressure gage where an indicator needle moves back and forth, the Swiss-made SLM Electronic Gage presents a dot moving up and down on a TV-like (oscilloscope) screen. It shows *pressure at any instant*, and not merely peaks or averages. Thus the effect on cylinder pressure of valve and port operation, ignition, combustion, or timing can be readily observed. Extremely high sensitivity permits even minor variations in cylinder pressure to be greatly magnified and examined in detail.

The new SLM Sub-Miniature Pressure Gage (Model PZ-6) equipped with a specially adapted spark plug permits cylinder pressure measurements in unmodified internal combustion engines.

A new console model which includes associated Kistler Pre-Amplifier-Calibrator units, electronic switches and oscilloscopes, displays up to eight cylinder pressure signals simultaneously. Simple gang connectors (summing units) permit eight *pressure rate* signals to be superimposed on the screen.

For manufacturing test, training, field engineering, field maintenance and service applications, the new portable SLM Engine Indicator-Analyzer is the most advanced equipment developed. Unlike conventional engine analyzers which show only ignition or vibration patterns, this Kistler package provides precision measuring instrumentation that fits readily into established maintenance procedures. For complete information, request Bulletins EA-114 and S-114.

Kistler Instrument Corp., Dept. SA, 15 Webster St., North Tonawanda, N. Y.

Briefs of SAE PAPERS

Continued from page 123

and V-16 Enterprise diesel engine for heavy duty marine and stationary power plants; criteria established are enumerated; advantages of V-engine over large bore in-line engine; types of connecting rod designs used; materials for rings and bearings; cost considerations and performance characteristics.

Stroboscopic Photography of Piston Cooling Oil Action, C. L. NEWTON. Paper No. 7B presented Jan. 1958, 7 p. Study and observation of cooling oil action in piston under simulated engine operating conditions using special photographic techniques is part of development program, carried out at Beloit Works of Fairbanks, Morse & Co.; diesel engine, designed for Snorkel application, is high speed, high output, opposed piston type with 6¾ in. bore and 8 in. stroke; test technique and equipment used; results.

Cummins Turbocharged Diesel Engines, N. M. REINERS, W. D. SCHWAB. Paper No. 240 presented Nov. 1957, 10 p. Recent developments include improvement of turbocharger component efficiencies, application of automotive concept of matching turbocharger to engine, and development of aneroid control; two turbochargers released for production have sufficient capacity and range to cover Cummins engine line from 4-cyl engine at 125 hp up to and including V-12 engine rated at 600 hp; performance curves.

Fell Diesel Mechanical Locomotive, L. F. R. FELL, G. M. BARRETT. Paper No. 245 presented Nov. 1957, 31 p. Principles of operation, important components and prime movers of prototype locomotive, No. 10,100 of 2-D-2 type, built by British Railways; four Paxman 12-cyl RPH diesel engines supply power for traction and two 6-cyl AEC type A210D engines supply auxiliary equipment; results of tests.

Essential Components of Efficient Maintenance: Engineering and Training, J. P. MORELAND. Paper No. 242 presented Nov. 1957, 9 p. Approach to maintenance of fleet operations recognizing engineering as one of most essential components of efficient maintenance; details of maintenance study program practiced at Fifth Avenue Coach Lines, Inc., New York, N. Y.; training program and technical education.

Carburetor Icing Demonstrator, I. T. ROSENLUND. Paper No. 244 presented Nov. 1957, 6 p. Aspects of carburetor icing and interrelationship of

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Briefs of SAE PAPERS

Continued from page 124

fuel volatility and atmospheric conditions with ice formation; use of two types of anti-icing additives; one class includes polar compounds having great affinity for metals and other materials which combine with condensed moisture having great affinity for water; features of field demonstration engine, developed to show effectiveness of anti-icing additives.

Turbocharger Shaft Dynamics, C. N. FANGMAN, J. L. HOFFMAN. Paper No. 7A presented Jan. 1958, 14 p. Requirements of high speed turbocharger systems in diesel engines for earthmoving machinery; factors contributing to instability of turbocharger system are investigated using special devices to measure vibrations associated with turbochargers; results show that two important vibrations are forced vibrations caused by unbalance and oil film whirl vibrations caused by hydrodynamic forces.

Some Reflections on Trends in Tractor Design, Performance and Cost, B. G. RICH, W. H. WORTHINGTON. Paper No. 13B presented Jan. 1958, 13 p. Changes in tractors produced by Deere & Co. between 1935 and 1957; considerations of horsepower, weight and drawbar pull; major changes in fuel trends; hydraulic control of implements; operation convenience and comfort; prices; comparison of equipment used with 1935-B and 1957-520 lines of tractors.

Driver's Viewpoint — Truck Driver's Office, J. GAUSSOIN. Paper No. 19C presented Jan. 1958, 3 p. Suggestions for truck design alternations presented; relocating dimmer switch; brake pedal; switch location vs. gage location; driver's position; windshield wipers and washers; color of turn signals.

Designs of Current Cabs and Future Prospects, T. ORNAS. Paper No. 19A presented Jan. 1958, 6 p. Two most important factors influencing cab design are problem of driver comfort and safety and demand for shorter bumper to back of cab dimensions how these problems are solved in heavy, medium and light duty trucks, and in utility vehicles; future trends.

Bio-Technical Aspects of Driver Safety and Comfort, R. A. McFARLAND, R. G. DOMEY. Paper No. 19B presented Jan. 1958, 29 p. Aspects of bio-technology in trucks; basic principles; variables influencing efficiency of operation, visual efficiency, comfort and safety; variables affecting sensory input; variables influencing response output, such as fixed limits of working space, seating and human sizing, and hand and foot control.

Continuous Radiotracer Monitoring Shows How Piston Hings Wear in Service, J. S. BATZOLD, J. V. CLARKE, Jr., J. F. KUNG. Paper No. 16C presented Jan. 1958, 23 p. Engine of passenger car studied was equipped with radioactive top compression rings; wear determined by monitoring crankcase oil for radioactive iron originating from piston rings; wear rates obtained were same as those observed in actual passenger car service, demonstrating that significant results in terms of field performance can be obtained by tests of relatively short duration with radioactive rings.

NUCLEAR ENERGY

Prospects for Economic Atomic Power, A. PUISHES. Paper No. 850 presented Nov. 1957, (North Calif. Sec.) 11 p. Discussion limited to generation of central station power for civilian use; present situation in United States and future prospect with regard to competitiveness; typical bus-bar costs from conventional plants; predicted atomic generation costs; comparison of construction costs; how costs will de-

Continued on page 127

Briefs of SAE PAPERS

Continued from page 126

crease through scientific development, advanced concepts, etc.; foreign market for atomic power.

PRODUCTION

Quality Control Through Engineering, Manufacturing, and Dealer Service, C. T. DOMAN. Paper No. S48 presented Feb. 1958, (Metropolitan Sec.) 11 p. Means by which quality levels are controlled or corrected at Ford Motor Co. center around customer's reaction to product and involve dealer service, engineering, manufacturing or sales policies; Quality Audit Program is concerned with handling of warranty claims, statistical analysis of repair orders. Customer Acceptance Survey, Product Problem Report, Public Relations Department, etc.

MISCELLANEOUS

What's in Future, I. McNAB. Paper No. S28 presented Oct. 1957, (Alberta Sec.) 9 p. Automotive research within General Motors organization and achievements brought forth; work covered on proving ground; speculations with regard to future developments in following areas: engine and fuels, free piston design, atomic and solar energy, trim and finish, brakes, wheels and tires, body and sheet materials, and possibilities of magnesium, titanium and zirconium.

Design Engineer in Industry, R. S. FRANK. Paper No. S37 presented Nov. 1957, (Mid-Continent Sec.) 5 p. Lack of interest in design engineering as career is due to misunderstanding of area; role of machine designer discussed from standpoint of diesel engine design field; how design engineer must apply knowledge of engineering fundamentals, shop practices, fabricating techniques and familiarity with available facilities of company; practices followed at Caterpillar Tractor Co. in training and advancing engineers.

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Reader Information Service" blank on page 5 corresponding to the numbers appearing after the titles of the digests of interest to you.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

New Members Qualified

These applicants qualified for admission to the Society between April 10, 1958 and March 10, 1958. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Thomas Starr Icke (A), Elmer Seidel (A).

Atlanta Section

Harvey C. Christen (M).

Baltimore Section

Charles B. Voitelle (M).

British Columbia Section

J. S. McDuff (M).

Canadian Section

Earl J. Servos (M).

Central Illinois Section

Kenneth W. Campen (J), Ralph J. Charter (A), James H. Heifner (J), Albert Lees (J), Harvey Warren Liberman (J), Robert Charles Louie (A),

Continued on page 129

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TEST FOUNDRY FACILITIES
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Chicago Section

Richard P. Clemmer (M), G. E. Doherty (A), Robert H. Ebert (A), C. A. Kroft (M), Dean A. Matthews (J), Jack E. Maxcy (J), Walter Penzias (M), Dean S. Robertson (M), Richard S. Roeing (M), Willard F. Wadt (M).

Cleveland Section

Paul C. Augustine, Jr. (J), Robert W. Biggs (M), Frederic W. Black (M), Edward A. Brittenham, Jr. (M), Harry Clary (M), Walter A. Fritsch (M), Arnold H. Hoffer (M), Frank A. Jeffries (M), Raymond H. Klein (M), Clifton W. Perryman, Jr. (A), Charles D. Thompson (M).

Dayton Section

H. Frederick Hess, Jr. (M), Eldon Ray McClure (J), Joseph R. Stormer (J).

Detroit Section

Arthur A. Adams (M), Guy L. Barnes, Jr. (J), Harold E. Barnum (M), James Berry Bragaw (A), Albert W. Brownes (J), Robert Buchanan (M), Thomas E. Burke (A), Robert A. Burton (J), James O. Cardot (J), Richard A. Carlson (M), Jack M. Clanton (M), Granville R. Conrad (M), William W. Dodson (M), John E. Eckenrode, Jr. (A), Charles E. Edwards (M), John Frederick Goodspeed (A), George A. Grossman (M), Robert J. Hampson (M), Robert D. Harrison (M), Stanley Edward Hildebrand (A), Paul P. Huber (J), Robert Donald LeWitter (A), Wynne R. Lilly (M), Leo Joseph Linsenmeyer (J), William C. Long (A), Robert B. Longmuir (J), Stanley E. Mallen (M), Paul Louis Martin (M), Raymond Arthur McAlpine (J), E. Ray Morrill (M), Frank A. Novak (M), Stanley Parr (J), Ralph C. Petersen (M), John H. Qualls (J), Habibur Rahman (J), William Reynolds (A), Clarence B. Richey (M), Charles Roberts Russell (M), John Warren Sawyers (J), Wayne C. Shanks, Jr. (M), Robert Arthur Shuman (J), Charles L. Stevens (M), Michael Tsou (J), C. E. Valentine, III (J), Harold L. Vogler (A), Thomas E. Zimmerman (J).

Hawaii Section

Harold D. Andrade (M), Edward V. Kawders (A).

Indiana Section

Gerard L. Baumes (J), Russ Byram Dhondy (J), John J. Ingellis (M), John K. Knighton (A), Walter F. Weiss (J).

Kansas City Section

David C. Goldberg (M).

Continued on page 130

New Members Qualified — cont.

Metropolitan Section

Stuart C. Bachman (M), Leonard Daum (M), Richard B. Ferris (A), Paul A. Larivee (M), Mark E. Otterbein (M), Paul J. Trojan (M), Warren E. Turner (M), Morris Leon Wade (M), Maurice Wellner (A).

Mid-Continent Section

Jack E. Foley (M).

Mid-Michigan Section

George Arthur Brown (M), Leroy Huelskamp (M), William James Johnston (J).

Milwaukee Section

G. Dean Cannon (A), John C. Heyvaert (A), Rudolph H. Schneider (M), Willis S. Scholl (M).

Montreal Section

Andre Veronneau (J).

New England Section

Peter Brownell (M), Francis L. Federhen (A), C. Perry Giddings (A).

Northern California Section

Walter Henry Giese (A), J. C. Gudgel, Sr. (A), Bevan Herbert Johnston (J), John Walter Parks (J), John Luther Scruggs (A), William F. Sternberg (M).

Northwest Section

John A. Ardington (M), William F. Duft (A).

Oregon Section

Riley Owen Montgomery (A), E. A. Paulson (A).

Philadelphia Section

Edward G. Barry (J), Paul Louis Gerard (J), S. Peter Kaprielyan (M), Robert M. Kennedy (M), Richard M. Lawrence (J).

Pittsburgh Section

Charles G. Kiskaddon, Jr. (A), Joseph F. Rudzki, Jr. (J).

St. Louis Section

Andrew A. Baumann (M).

Salt Lake Group

John S. Morton, III (A).

San Diego Section

Sumner Alpert (M), Loren D. Hamlin (M).

Southern California Section

J. D. Birdwell (J), Leslie David Conyers (A), Allan B. Fredhold, Jr. (M), Harold T. Glenn (A), Sidney Lampert (J), Patton Lewis (M), William W. Saxton (M), Alexander Alley Smith, Jr. (M), W. F. Snelling (M), Frank L. Spencer (A), M. H. Sperling (M), Henry A. Traub (M), William Albert Winter (M).

Southern New England Section

F. D. Bryant (A), Elliott L. LaMontagne (A), John A. Lozzi (M), Harold S. Moore (M), Russell A. Schwarzmann (J).

Spokane-Intermountain Section

Henry N. Ard (M), Francis O'Conner (A).

Twin City Section

Sherwood R. Mickelson (A).

Washington Section

George R. Petty, Jr. (M)

Western Michigan Section

Stuart F. Kutsche (M), Harold Vaughn Lindow (A).

Williamsport Section

Rolf Schaffranke (M).

Outside of Section Territory

Donald D. Baker (J), W. C. Bowers (M), Barnett Frumkin (M), William A.

Continued on page 133

New Members Qualified — cont.

Graf (M), Turner L. Miller (M), Arnold B. Skromme (M), Robert Duane Strohl (J), Luther Hill Waller, Jr. (M).

Foreign

R. Gopalkrishnan (J), South India; Edgar Knoop (M), Germany; Antonio Hideto Kobayashi (J), Brazil; Robert Leadbitter (A), Bermuda; James E. Lyle (M), Mexico; Donald H. McGown (M), Holland; Monty I. Prichard (M), England.

Applications Received

The applications for membership received between March 10, 1958 and April 10, 1958 are listed below.

Alberta Group

Joseph George Wise

Baltimore Section

Therman L. Robinson, Lt. Alexander E. Waller

British Columbia Section

Kelvin S. Fowler, Alan E. Hooper, F. W. I. Merritt, Verne Preston Taylor

Canadian Section

Harold A. E. Burgess, David Scott Fisher, Roger Eugene Hatch, Reginald Arthur Hill, Curtis Arthur Parkinson, William G. Preece, E. Ralph Rowzee

Central Illinois Section

John W. Buckstead, Robert Charles Ebrecht, Clifford E. Johnson, Vernon L. Keagy, Bernard J. McGuire, George I. Pigman, Hudson B. Scheifele, Paul E. Schleder, Ernest W. Wagner

Chicago Section

Ben S. Barrett, Peter P. Bishop, Edwin P. Easterday, Karl Gallwitz, George A. Grassby, John J. Haunschild, William M. Phalen, G. Robert Reynolds

Cincinnati Section

Walter S. Bertaux

Cleveland Section

Richard B. Belford, Charles Robert Bright, Gerald W. Hicks, Roland C. Kleinfeld, Neil Irwin Leffler, Robert L. Morse, John Andrew Rade, Joseph J. Repko, Wellington G. Scheid, Harry W. Stanhope

Dayton Section

Charles S. Stultz

Detroit Section

Carl L. Betteridge, Henry K. Borden, Anil Kumar Chaudhuri, David A. DeLong, Vistor Emery, Ashley J. Freehan, Andrew E. Geddes, Donald Ray Herda, Edmond E. Madion, Guy G. Manuel, William P. Pautke, Charles W. Phelps, Carey M. Rhoten, Ray G. Rhoton, Joseph B. Sablacan, Paul J. Steil, William Fong Yee

Indiana Section

Ronald L. Alt, Hugh C. Kirtland, Ralph J. Magnus, John K. Mason, George E. McIntosh, Elton L. Thompson, Kenneth N. Vaughan.

Kansas City Section

Joseph W. French, John Suprock

Metropolitan Section

Frederick J. Borheck, George E. Brayman, Arthur H. Church, Philip E. N. Greene, Jr., Lawrence M. Holzapfel, Edward C. Joles, William E. Lovett, Richard S. MacCrea, Frank Marold, William Martino, Andrew V. Santulli, Adolf Vartanian

Mid-Continent Section

Charles S. Parker, Jr.

Mid-Michigan Section

Walter J. Banacki, Jr., Arthur J. Olmsted, Leo W. Tobin, Jr.

Milwaukee Section

John Robert Bonner, Robert Edwin Harloff, Charles A. Werve

Mohawk-Hudson Section

John C. Rabetz

Continued on page 134

Applications Received — cont.

Montreal Section

William M. Brownlee, Frank R. Richmond

New England Section

H. Joseph Howard, Ronald Alton Pick, Robert H. Thesing

Northern California Section

Eugene R. Rhea

Northwest Section

Robert George Steiner

Oregon Section

Charles H. Hall, Harry J. West

Philadelphia Section

Dominick Fella, Walter Wycliffe Owen, John William Yaag

Pittsburgh Section

G. J. Otto, Arthur C. Toner, Jr.

San Diego Section

William Lewis Eckhart, James K. Marechal, Jr.

Southern California Section

W. C. Avrea, John Calvin Closson, Ray H. Hahn, Edgar Jerome Jones, Raymond W. Mattson, John H. Norton, John Louis Nuchols, Jerry K. Samp

Southern New England Section

David G. Blackburn, Robert L. Fish, Louis A. Gaumond, Warren Ross Jensen, Erwin Mooney, Wayne Stone

Spokane-Intermountain Section

Robert M. Ball

Syracuse Section

Arthur C. Lyman, Jr.

Texas Section

Calvin L. Habern, Harrell E. Haney

Texas Gulf Coast Section

James A. Haney

Western Michigan Section

James R. Andres, Jack L. Conley

Williamsport Group

Thomas L. Holland, Cecil C. Rhodes

Outside of Section Territory

Edward K. Dunnett, Frank H. Lemons, Peter B. Mitchell, V. Saravana Perumal, Billy B. Roy, Adolph M. Stejskal, David E. Stover, Richard A. Wittren

Foreign

Dr. Ing. Heinz W. Balster, Germany; Ralph Day, South Africa; Gunnar Ljungstrom, Sweden; Dr. Karl-Heinz Muhr, West Germany; Alfred Xavier Napoles, Cuba; Mohamed Nabil Reda, Saudi Arabia; Alfred Cecil Whitehorn, England

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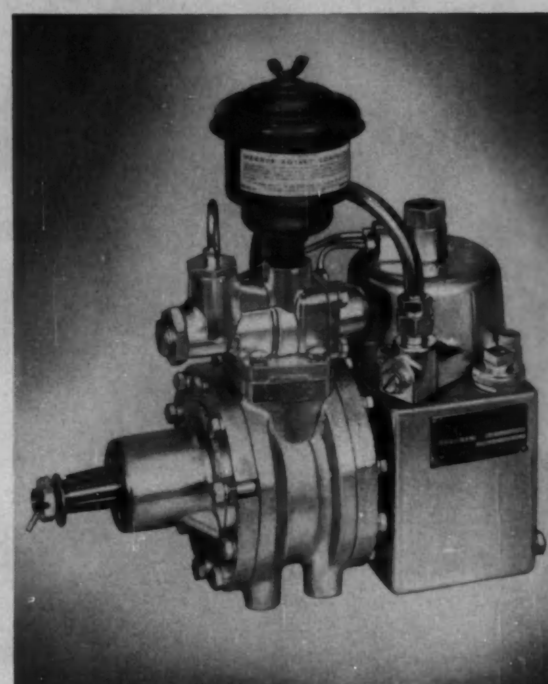

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The engineer shown here has just completed simulated high-altitude tests on a new shielded insulation that comes a step closer to meeting the needs of interplanetary space travel.

Down-to-earth laboratory research like this is the Auto-Lite way of serving industry by doing tomorrow's job today. Through research, Auto-Lite serves industry better by supplying products of highest quality today while looking ahead to maintain tomorrow's leadership.

The attitude of quality today and even better products tomorrow is the operating theme behind twenty-nine Auto-Lite plants in twenty-three communities throughout the United States and Canada. The high quality of more than 400 products made by Auto-Lite is a reflection of this attitude.

Whether it be intricate die castings, wire for modern aircraft, electrical equipment for the automotive industry, or any one of hundreds of other products . . . it serves best when it comes from Auto-Lite.

THE ELECTRIC AUTO-LITE COMPANY • Toledo 1, Ohio

AUTO-LITE® *Manufacturers of...*

SPARK PLUGS • BATTERIES • BUMPERS & GRILLES • GENERATORS • IGNITION UNITS
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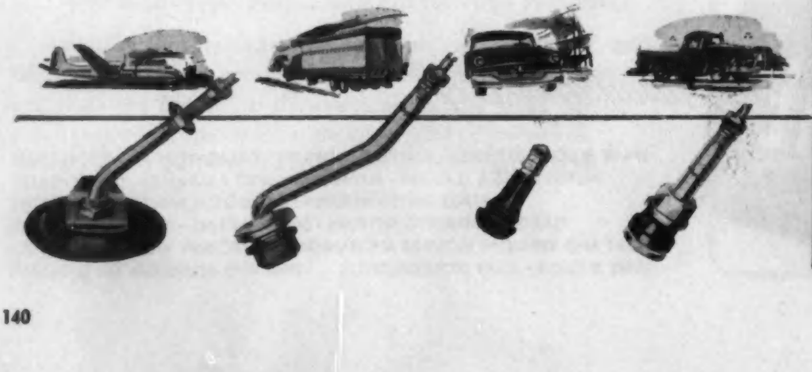
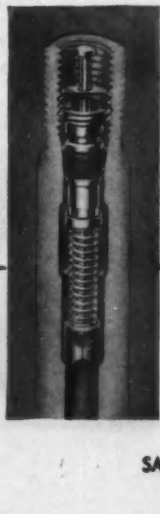
SEAT AND WINDOW MOVING MECHANISMS • SWITCHES • WINDSHIELD WIPERS
WIRE & CABLE • GRAY IRON CASTINGS . . . ZINC AND ALUMINUM DIE CASTINGS

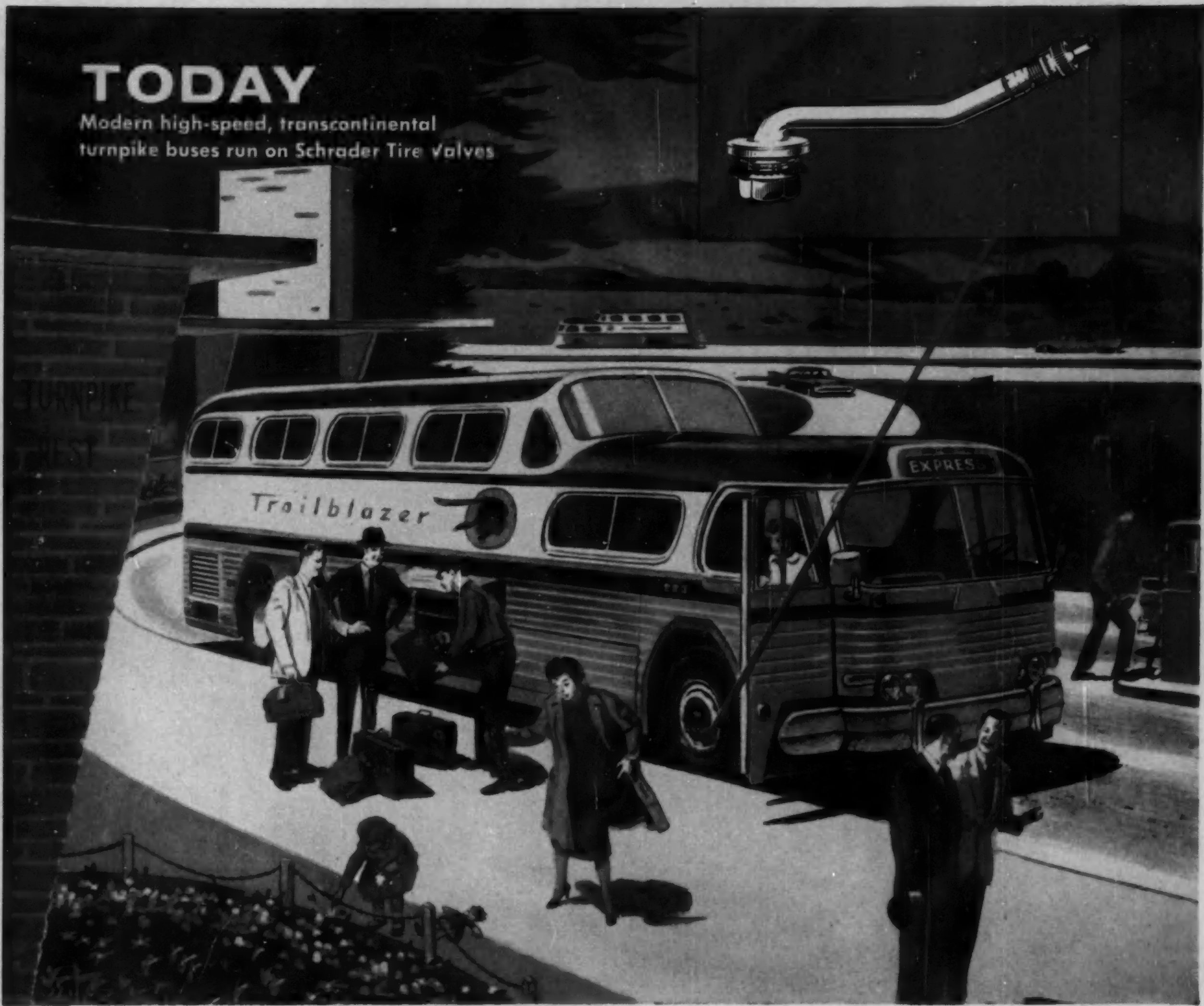
OUTSTANDING TIRE

ACE OF STANDARDIZATION

the name for Schrader's famous tire valve operating principle






TODAY
Modern high-speed, transcontinental turnpike buses run on Schrader Tire Valves
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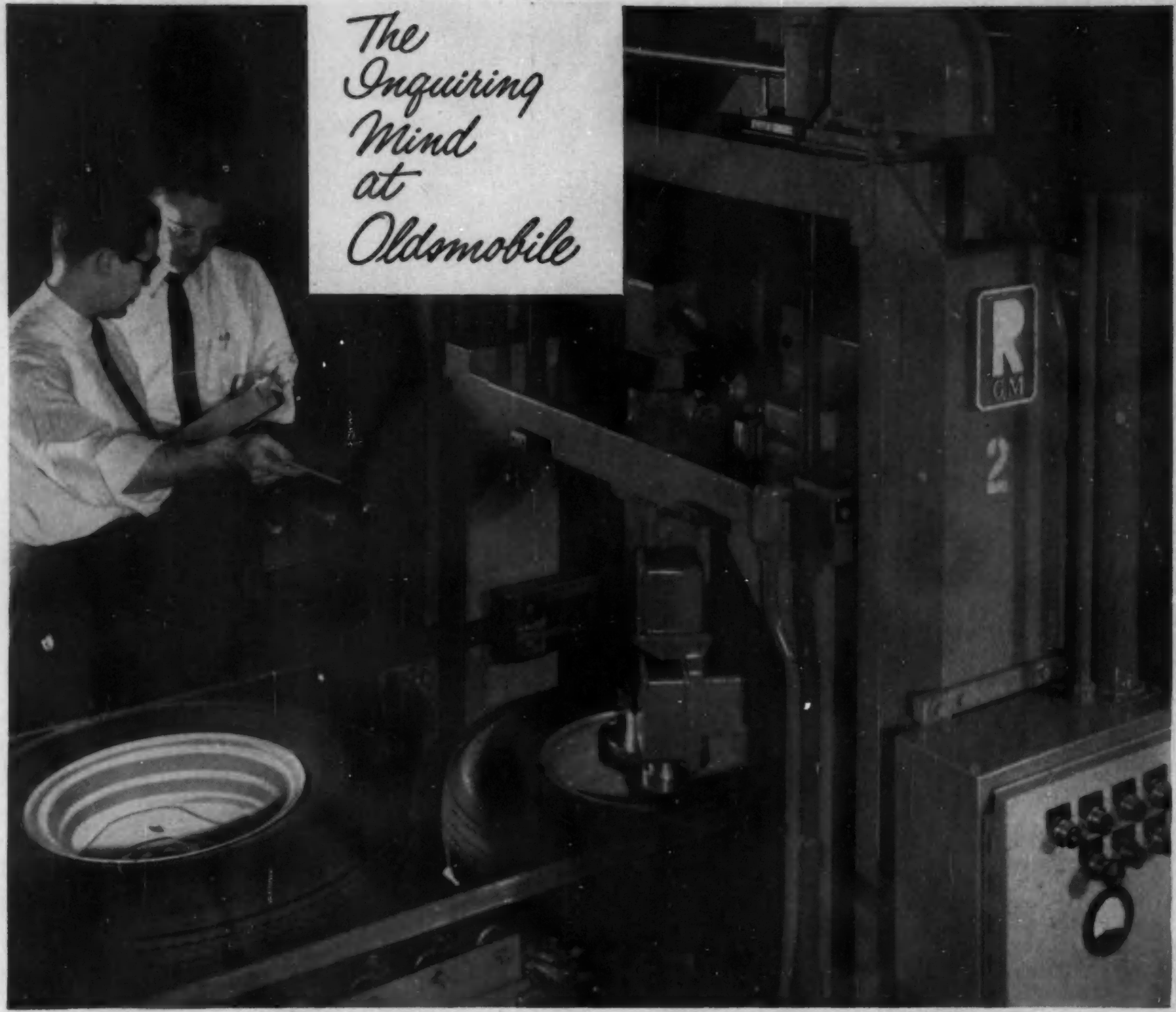
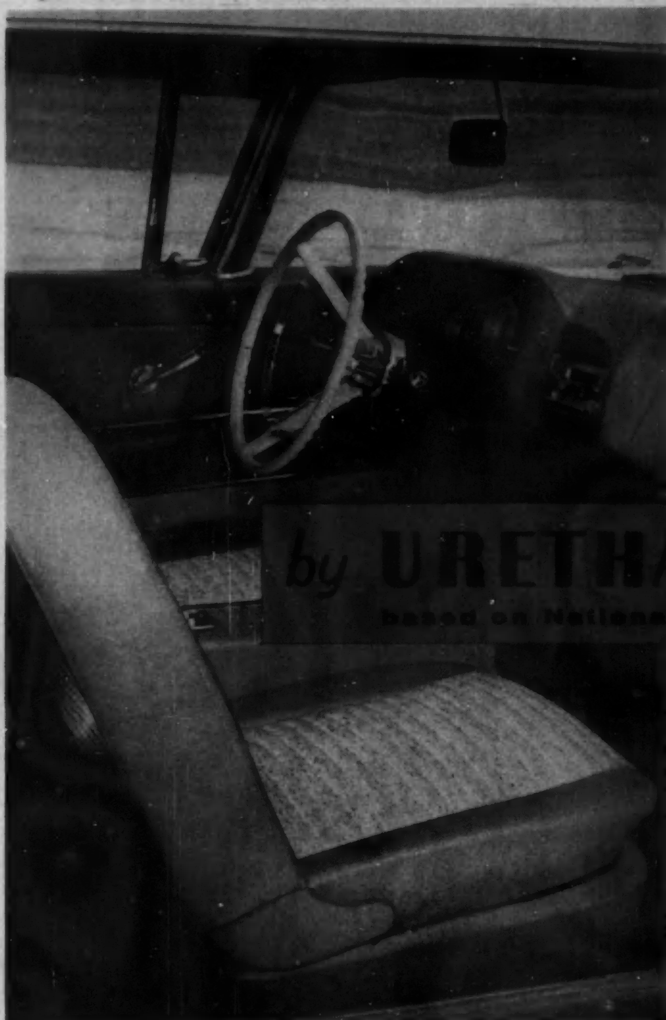

The Inquiring Mind at Oldsmobile
R
GM
2



America Rides Cushioned and Cooled

by URETHANE FOAM!

based on National Aniline's NACCONATES®

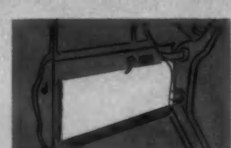
More and more, urethane foams are used in cars for crash-padding, comfort cushioning, insulation and vibration dampening! Labor-saving fabrication and low cost make them doubly attractive in a dozen different applications.

They are extremely versatile cushioning materials. Resilience can be controlled to provide comfortable seating or impact-absorbing safety pads.

Either topper-pads or full thickness seat cushions can be bonded to outer coverings for snug, permanent fit. Arm rests, luxuriously padded interior panels and rug underlays can be made by one-operation foaming-to-fabric.

Thin headliners afford remarkable protection against summer sun and winter's cold. In air-conditioned cars urethane foams can provide insulation throughout...and soundproofing against road noises, too! When rigid foams are used they add lightweight structural support.

As makers of NACCONATE® diisocyanates, chemical components in urethanes, National Aniline is ready now with competent technical assistance for automotive engineers, designers and suppliers who wish to capitalize on this material. Your letter will bring prompt response.



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NATIONAL ANILINE

Allied Chemical

4 EXAMPLES

of many thousands

SHOWING *Why*

PIONEER 921-T

TOOLING PLATE is the choice of TOOL ENGINEERS

Pioneer 921-T Cast Aluminum Tooling Plate can be adapted to any precision tooling job without preliminary milling. Every Pioneer 921-T plate, ¾" or more in thickness, is held within a flatness tolerance of .010" in all directions. It is extremely stable, weighs 60-70% less than tool steel and possesses high tensile strength. The special aluminum-titanium alloy composition of Pioneer 921-T and method of casting insures uniformity, and guarantees freedom from porosity, distortion and casting defects. Being easily sawed, tapped, milled or welded, Pioneer 921-T is a universal tooling metal, saving material, time and man hours to reduce overall tooling costs.

At the left are shown a series of precision fixtures in which Pioneer 921-T was used in order to meet close tolerance requirements in the manufacture of a jet fuel component. Mail the coupon and receive free, all issues of TOOL TALK, presenting new and unusual applications of Pioneer 921-T.

SPECIFY PIONEER 921-T AND ORDER FROM THESE METAL SUPPLIERS

ALBUQUERQUE, N.M.: Morris Steel & Supply Co.
ATLANTA, GA.: Reynolds Aluminum Supply Co.
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DEARBORN, MICH.: Pioneer Aluminum Inc.
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DETROIT, MICH.: Kasle Steel Corp.
Meier Brass and Aluminum Co.
GRAND RAPIDS, MICH.: Kasle Steel Corp.
HARTFORD, CONN.: American Steel & Aluminum Corp.
HILLSIDE, N.J.: Edgcomb Steel & Aluminum Corp.
HOUSTON, TEX.: Vinson Steel and Aluminum Co.
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KANSAS CITY, MO.: Industrial Metals, Inc.
LOS ANGELES, CALIF.: Bralco Metals Co., Inc.
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Tool Components, Inc.
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MEMPHIS, TENN.: Reynolds Aluminum Supply Co.
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MILWAUKEE, WIS.: Joseph T. Ryerson & Son, Inc.
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RICHMOND, VA.: Reynolds Aluminum Supply Co.
ST. LOUIS, MO.: Industrial Metals, Inc.
SOUTH BEND, IND.: Kasle Steel Corp.
TULSA, OKLA.: Industrial Metals, Inc.
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PIONEER ALUMINUM INC. SAE-5-58
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Los Angeles 45, Calif.
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TOOLING PLATE
HEATING PLATENS
VACUUM CHUCKS
EXTRUSIONS

DELCO HIGH POWER TRANSISTORS are made from

GERMANIUM

because it alone combines these 5 advantages:

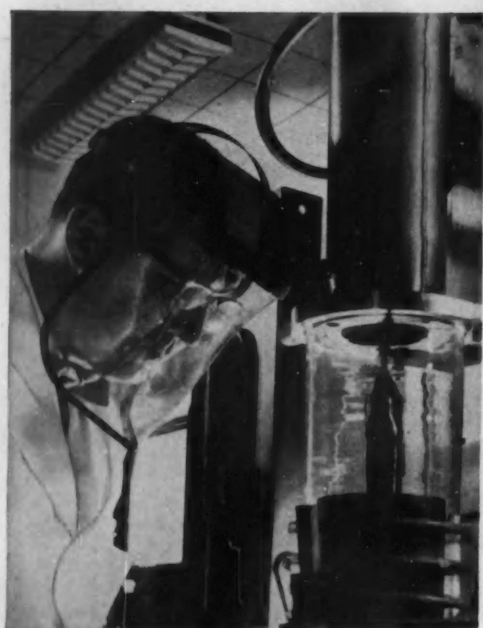
Lower saturation resistance—Germanium gives Delco High Power transistors a typical saturation resistance of only *3/100ths* of an ohm. No other present material offers this characteristic, which permits efficient high-power switching and amplification from a 12- or 24-volt power supply.

Higher current gain—Gain with germanium is not only higher but is more linear with current.

Lower distortion—In many applications, distortion requirements can be satisfied only with germanium transistors.

Lower thermal gradient—As far as deliverable power of present devices is concerned, germanium meets the need and, in addition, provides a thermal gradient of only 1.2° C/watt.

Greater economy—More power per dollar.



In the center of the quartz housing, a germanium crystal is being grown. A "perfect crystal lattice," it will be cut into wafers 3/10ths of an inch square and less than 1/100th of an inch thick to become the heart of Delco High Power transistors.

Examine Delco High Power germanium transistors and see how practical it is to go ahead with your plans now. For high current applications there is no better material than germanium, or Delco Radio would be using it. All Delco High Power transistors are produced in volume; all are normalized to retain their fine performance and uniformity regardless of age. Write for engineering data and/or application assistance.

DELCO RADIO

Division of General Motors, Kokomo, Indiana

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No break-in... no run-in period with IPC "square shoulders"

IPC's square shouldered cup and "U" packings are *formed to the shape your leather packings will take under high pressure.*

What does this mean? In terms of the many high pressure applications for small cylinders which operate on fast cycles it means *immediate sealing.* No break-in or run-in period is necessary.

You will not be reshaping the shoulders of conventional leather cup or "U" packings to assure positive sealing. More . . . you'll eliminate excessive strains and resulting weaknesses of the leather by not having to reshape your packings in the application.

IPC "endgrains" and molds leather packings in both cup and "U" shapes from the world's finest materials. Whatever your packings problems . . . it's worth the time to check IPC's "custom approach." A complete and experienced engineering staff is available to assist you with any sealing application.

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Packings
Oil Seals
Precision Molding

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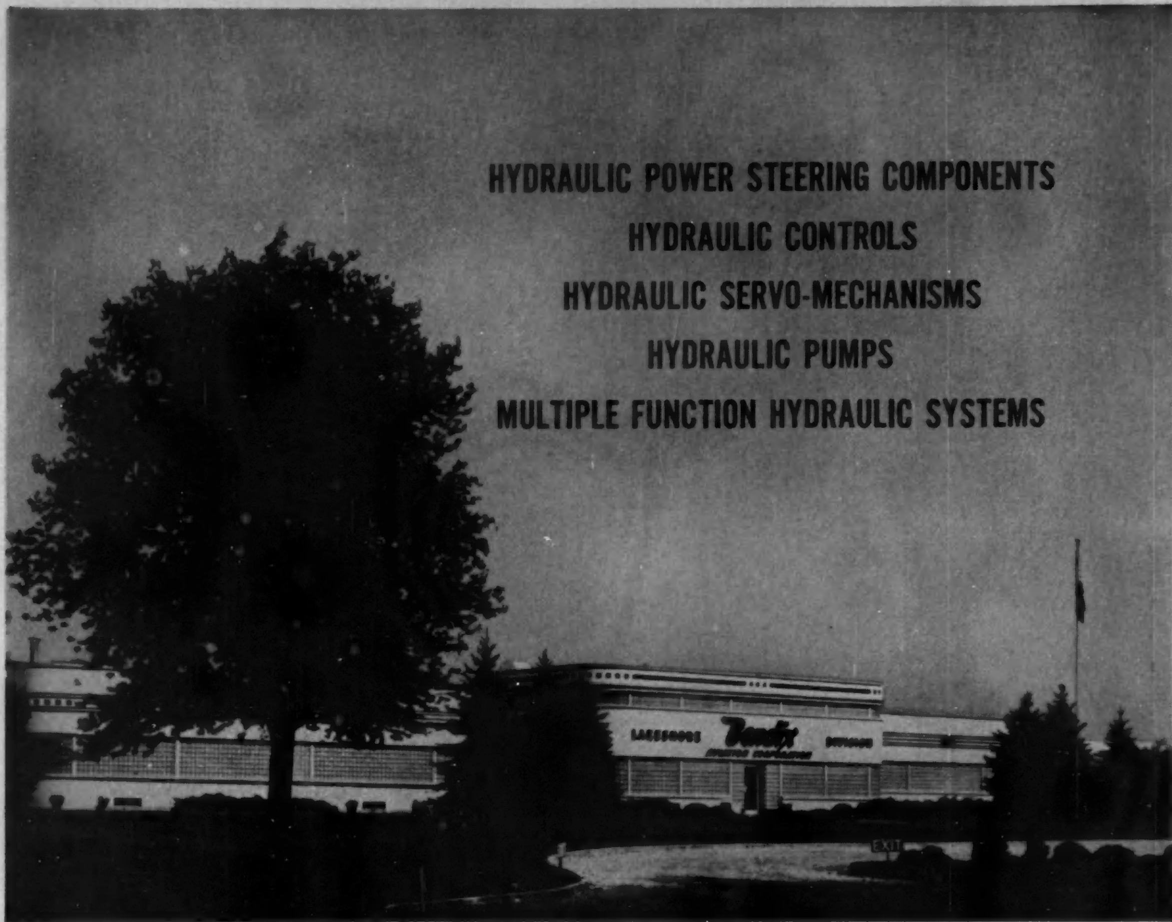
Bristol, New Hampshire P3



IT'S BENDIX-LAKESHORE FOR COMPLETE HYDRAULIC ENGINEERING AND MANUFACTURING

—Automotive or Agricultural—

Whatever your needs in agricultural or automotive hydraulic components, you'll be wise to look first to Bendix-Lakeshore. One of the newest and most modern divisions of the great Bendix Aviation Corporation, Bendix-Lakeshore is geared to provide you with fast, efficient service on any product, whether it's designed by our own skilled engineering staff or produced here from your design.

Despite being a comparatively new division, Lakeshore is old in experience. Backed by the great resources of Bendix Aviation Corporation, it is staffed in large part by engineers who have spent an aggregate of hundreds of years in hydraulic research and design, both with Bendix* and other firms. Solid engineering research and extensive testing are standard procedure with us. When you order hydraulic components from Bendix-Lakeshore, you get the benefit of complete engineering facilities.

Bendix-Lakeshore's reputation for quality in the field of hydraulic components has helped us acquire, in the space of five years, a list of customers whose standards are beyond question. Remember, if you have a problem in engineering or manufacturing of automotive or agricultural hydraulic components, it will pay you to investigate the facilities and abilities of Bendix-Lakeshore in these specialized fields.

*TRADEMARK

Lakeshore Division
St. Joseph, Michigan

Bendix
AVIATION CORPORATION

Gardner-Denver (Keller) 000RSD and 12A-2 screw drivers with cushion clutch, magnetic bit holder and Phillips insert bit assembling dual headlights for 1958 cars.

These Air-Operated Screw Drivers Are Paying for Themselves

If you drive only 400 screws a day, a Keller air-operated screw driver, such as those shown above, will pay for itself in six months. These lightweight air tools are easier on their users . . . help them keep pace with fast-moving assembly-line work.

Despite their high load factor, Keller pneumatic screw drivers run cool always. They have the right combination of torque, adjustable clutch and magnetic holding of screws for fast, efficient driving. They are the modern way to reduce assembly-line time and costs.

Send for the 40-page booklet. This Gardner-Denver booklet gives complete information about Keller screw drivers and nut setters, as well as other Keller air tools and accessories. A copy is yours for the asking.

GARDNER-DENVER Since 1859

KELLER TOOLS

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

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REICHHOLD PRODUCTS	TYPE	FOUNDRY PROCESS	OUTSTANDING FEATURES
FOUNDREZ 7101,7102,7103,7104	Liquid Resin	CONVENTIONAL CORES (Sand, Cereal, Binder, Water)	High Hot Strength High Baked Strength
FOUNDREZ 7600,7601,7605	Liquid Resin		Rapid Collapsibility Fast Bake
CO-RELEES 7300	Oil		Excellent Sand Conditioning
coRCIment 7990,7991,7992,7993	Oil		Broad Baking Range Excellent Workability
FOUNDREZ 7150,7151	Liquid Resin	SHELL MOLDS AND CORES (Dry Sand, Resin)	Unusual Stability
FOUNDREZ 7500,7504,7506,7555	Powdered Resin		Self-Activation
FOUNDREZ 7520	Granulated Resin		High Tensile Strength
COROVIT 7201	Powdered Chemical Accelerator	SELF-CURING MOLDS AND CORES (Dry Sand, Binder, Accelerator)	Non-Toxicity
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For further information regarding any of these materials, write our Foundry Products Division at White Plains

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FOUNDRY PRODUCTS

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REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

NEW VICKERS® high performance vane pump

• high speed • high pressure • high efficiency • high service life

NEW COMPACT DESIGN . . . more than twice the horsepower of previous pumps in the same package size.

NEW VANE CONSTRUCTION . . . positive vane tracking at all speeds assures efficient operation at increased speeds and pressures.

NEW SIZES not previously available . . . answers mobile equipment designers' need for greater hydraulic horsepower in limited space.

NEW PARTS INTERCHANGEABILITY . . . many common parts for single and double pumps (two pumps on the same shaft in one envelope). Lessens inventory requirements.

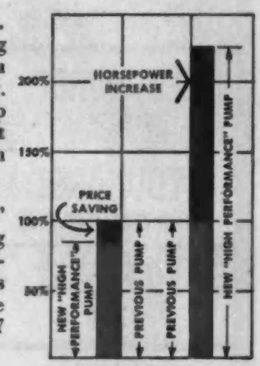
NEW 4-BOLT SAE FLANGE CONNECTIONS . . . will also accommodate user's 2-bolt flanges of the proper design.

NEW 2-BOLT MOUNTING (SAE 1959 STD.).

NEW REPLACEABLE PUMPING CARTRIDGE . . . all wearing parts of pump are incorporated in one replaceable cartridge. Easy field replacement without removing pump from its mount. Cartridges available in kit form.

MORE HORSEPOWER PER DOLLAR. The graph at the right makes a revealing comparison between this new pump and a previous pump of the same rated delivery. The new Vickers "High Performance" pump provides more than *twice the horsepower* at *less cost* while shrinking package size from 200 to 112 cubic inches.

The complete line of "High Performance" pumps (both single and double) is being readied for release. Size range will accommodate your largest requirements. This first model of the series is available in three ring capacities; 12 gpm, 14 gpm, and 17 gpm as shown in table below.



Model Number	Delivery-GPM 1200 RPM 100 PSI	Delivery-GPM 2000 RPM 2000 PSI	Input Horsepower @ 2000 RPM 2000 PSI	Package Size†	Weight
2V12A-**10	11.8	17.8	25.5	L. 5⅜" W. 4⅝" H. 5¾"	26 Lb.
2V14A-**10	13.6	20.4	29.0		
2V17A-**10	16.6	25.2	36.0		

†Exclusive of Shaft Extension and Mounting Lobes

8050

Write for new illustrated Bulletin No. M5108 for further details and performance characteristics.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1440 • Detroit 32, Michigan

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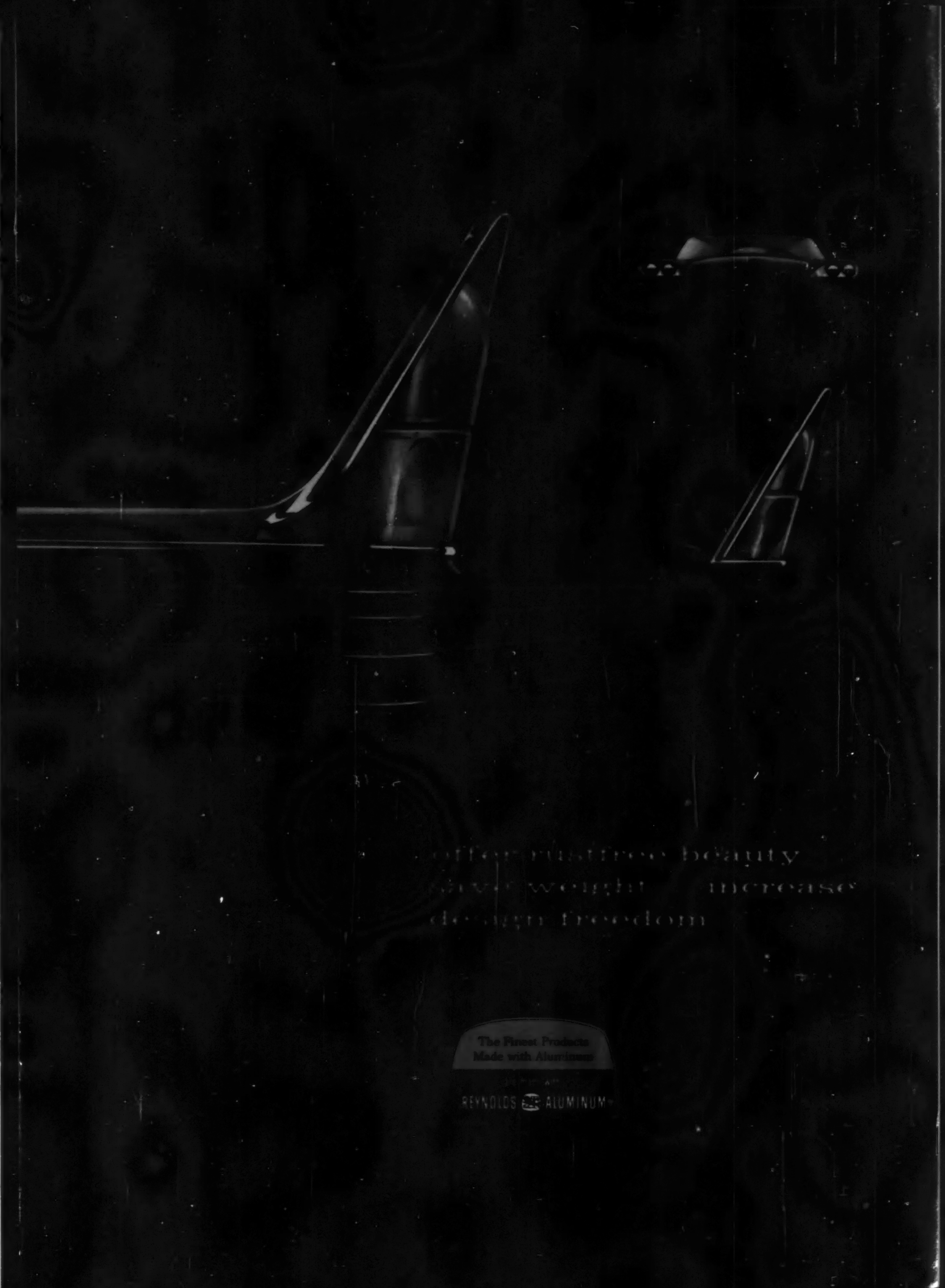
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921


offer rustfree beauty
save weight increase
design freedom
The Finest Products
Made with Aluminum
REYNOLDS ALUMINUM

Aluminum's flexibility in design, fabrication and finishes, offers a variety of sales appealing bumper ideas

Consider these aluminum bumper advantages:

- **Styling and design versatility.** With aluminum you are not limited to one finish—there are attractive new textures and finishes including clear and color anodized combinations with the "look of sterling" and "the gleam of gold". Contrasting colors can also be added through the use of organic finishes. And, paint films adhere to anodized aluminum remarkably better than to other materials used for decorative applications.
- **Long lasting beauty and economy.** Aluminum bumpers cannot rust—ever. Anodizing solves corrosion problems even with deep recesses that cannot be plated economically. Economy results from original production savings and reduced warranty costs.
- **Lighter weight.** Aluminum cuts "overhang" weight, can reduce total bumper weight by one-half, gives brakes less load to stop.
- **Fabricating savings.** *Extruded* aluminum bumpers, for example, can slash bumper tooling costs. Reinforcing members integral with bumper itself can be designed into either side for strength or beauty. If desired for style reasons, grooves also can be extruded for inserting bumper faces of other materials and colors. *Stamped* sheet aluminum bumpers can cut finishing costs—eliminate need for many finishing operations required with other metals.

On this application and on countless others, Reynolds Aluminum Specialists will be glad to work with you to help you get the very most from the aluminum you use. For details on this service and on aluminum mill products or fabricated aluminum parts and trim, call your nearest Reynolds Office. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan or P.O. Box 1800-MY, Louisville 1, Kentucky.*

NOTE: Before you buy any part—have it designed and priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower *final* cost.

The Finest Products Made with Aluminum

are made with

REYNOLDS ALUMINUM

Reynolds Aluminum

the metal for automation

TRADE MARK

Watch Reynolds All-Family Television Program, "DISNEYLAND", ABC-TV.

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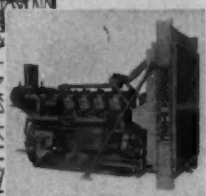
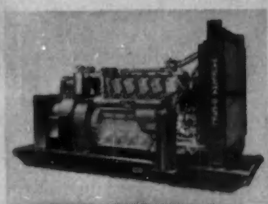
Normal and Turbocharged Diesels, Gasoline, Natural Gas, LPG ...
Standard or Counterbalanced Crankshafts

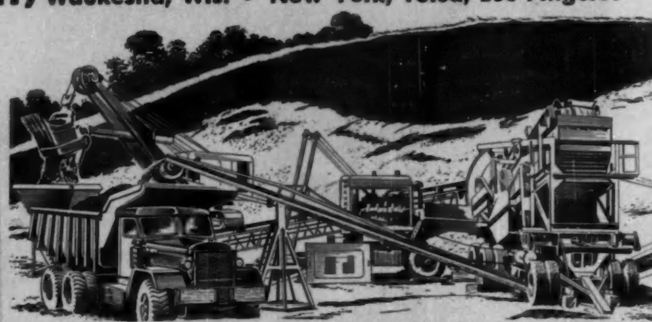
WAUKESHA MOTOR COMPANY, Waukesha, Wis. • New York, Tulsa, Los Angeles



Model VLRDBS

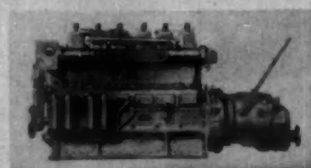


800 KW Enginator

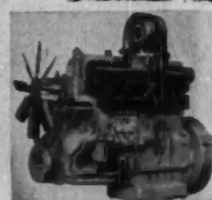


Displ. Cu. In.	Bore and Stroke	Standard Crankshaft Model	Standard Crankshaft HP @ RPM	Counterbalanced Shaft Model	Counterbalanced Shaft HP @ RPM	Features*
			NORMAL DIESEL ENGINES			
144	3½x3¾	....	....	180-DLC	45 @ 2400	4AOW
216	3½x3¾	185-DLC	60 @ 2400	....	....	6AOW
265	3¾x4	190-DLC	84 @ 2400	190-DLCA	85 @ 2800	6AOW
302	4 x4	195-DLC	96 @ 2400	195-DLCA	98 @ 2800	6ADO
302	4 x4	197-DLC	91 @ 2800	197-DLCS	131 @ 2800	6ADO
426	4¼x5	135-DK	140 @ 2400	135-DKB	147 @ 2800	6ADO
779	5¼x6	148-DK	197 @ 2000	148-DKB	200 @ 2100	6AOW
1197	6¼x6½	WAKD	224 @ 1600	WAKDB	258 @ 1800	6AOW
1905	7 x8¼	....	....	NKDB	297 @ 1200	6AOW
2894	8½x8½	....	....	LRDB	415 @ 1200	6AOW
5788	8½x8½	....	....	VLRDB	830 @ 1200	12AOW
			TURBOCHARGED DIESEL ENGINES-			
426	4¼x5	....	....	135-DKBS	185 @ 2800	6ADO
779	5¼x6	....	....	148-DKBS	280 @ 2100	6AOW
1197	6¼x6½	....	....	WAKDBS	352 @ 1800	6AOW
1905	7 x8¼	....	....	NKDBS	390 @ 1200	6AOW
2894	8½x8½	....	....	LRDBCS	695 @ 1200	6AOW
5788	8½x8½	....	....	VLRDBS	1235 @ 1200	12AOW
			GASOLINE, GAS ENGINES			
61	2½x3⅛	ICK	18 @ 3200	....	....	4ALN
133	3¼x4	FC	34 @ 2600	....	....	4ILN
144	3½x3¾	....	....	180-GLB	45 @ 2400	4AOW
186	3⅝x4½	XAH	47 @ 2200	....	....	4ILN
216	3½x3¾	185-GLB	67 @ 2400	....	....	6AOW
265	3¾x4	190-GLB	77 @ 2400	....	....	6AOW
302	4 x4	195-GL	85 @ 2400	....	....	6DAO
320	4⅛x4	195-GK	103 @ 2400	195-GKA	122 @ 3000 (F)	6ANO
404	4¼x4¾	MZA**	128 @ 2800 (F)	....	....	6ALN
426	4¼x5	135-GK	134 @ 2400	135-GKB	147 @ 2800 (F)	6ADO
451	4⅜x5	135-GZ	143 @ 2400	135-GZB	153 @ 2800 (F)	6ANO
525	4½x5½	140-GK	155 @ 2250 (F)	140-GKB	177 @ 2600 (F)	6AOW
554	4⅝x5½	140-GZ	170 @ 2250 (F)	140-GZB	188 @ 2600 (F)	6AOW
779	5¼x6	145-GK	216 @ 2000 (F)	145-GKB	240 @ 2400 (F)	6AOW
817	5⅜x6	....	....	145-GZB	260 @ 2400 (F)	6AOW
1197	6¼x6½	WAK	234 @ 1600	WAKB	280 @ 1800	6AOW
			GAS ENGINES			
1197	6¼x6½	WAKR	290 @ 1800	WAKB	300 @ 1800	6AOW
1905	7 x8¼	....	....	NKRB	343 @ 1200	6AOW
2894	8½x8½	....	....	LRORB	515 @ 1200	6AOW
3520	9⅜x8½	....	....	LRZB	590 @ 1200	6AOW
5788	8½x8½	....	....	VLROB	980 @ 1200	12AOW

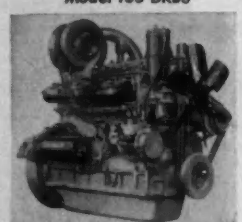
* Features: 4, 6, 12-Number Cylinders, A-Aluminum Pistons, D-Dry Sleeves, I-Iron Pistons, L-L-head, N-No Sleeves, O-Overhead Valves, W-Wet Sleeves.
** Also, with iron pistons for low speed service. (F)-Rated higher for fire service.



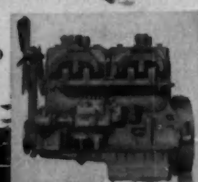
Marine LRDBM



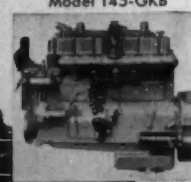
Model WAKDBS



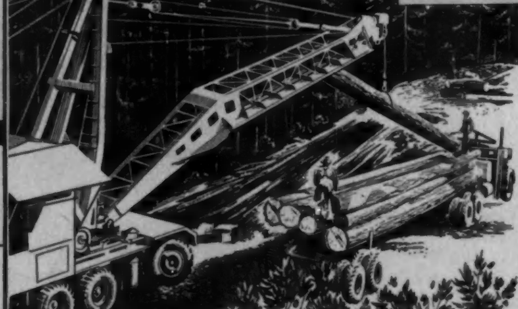
Model 135 DKBS

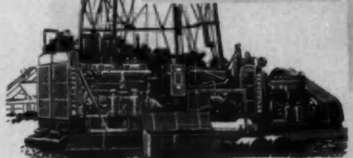


Model WAKD



Model 145-GKB





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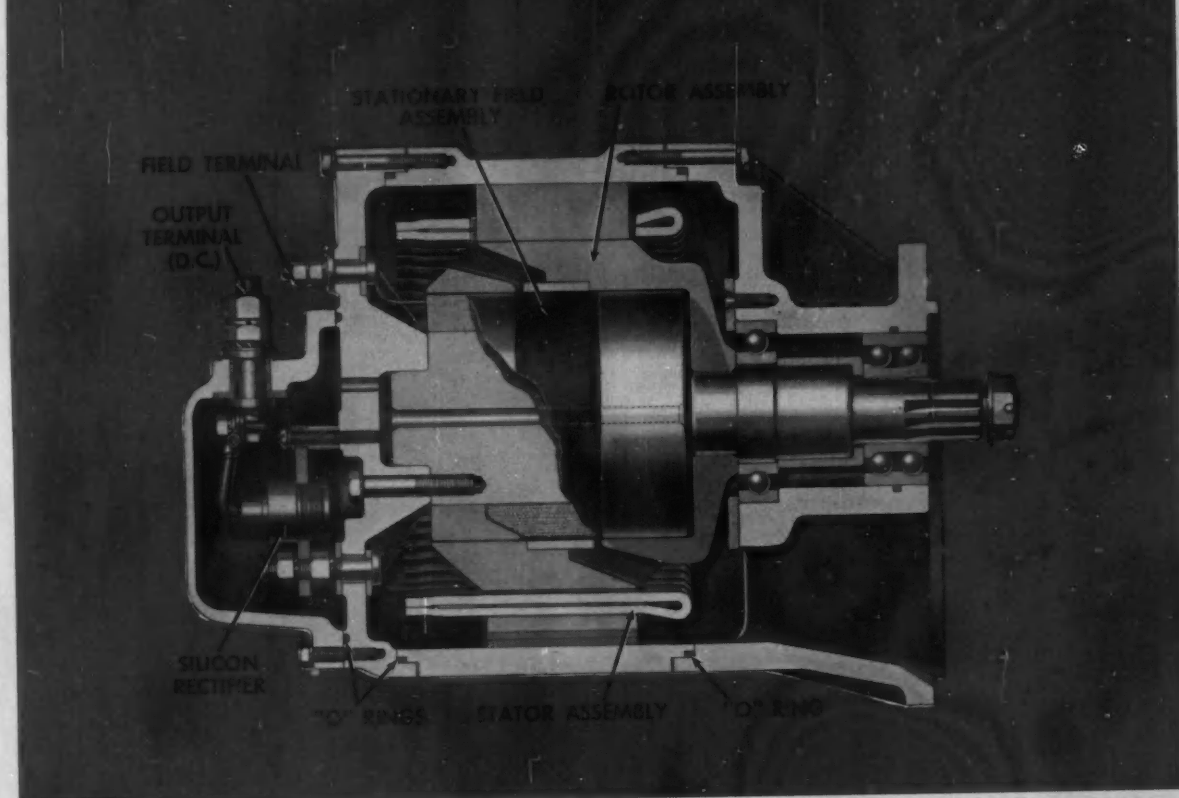
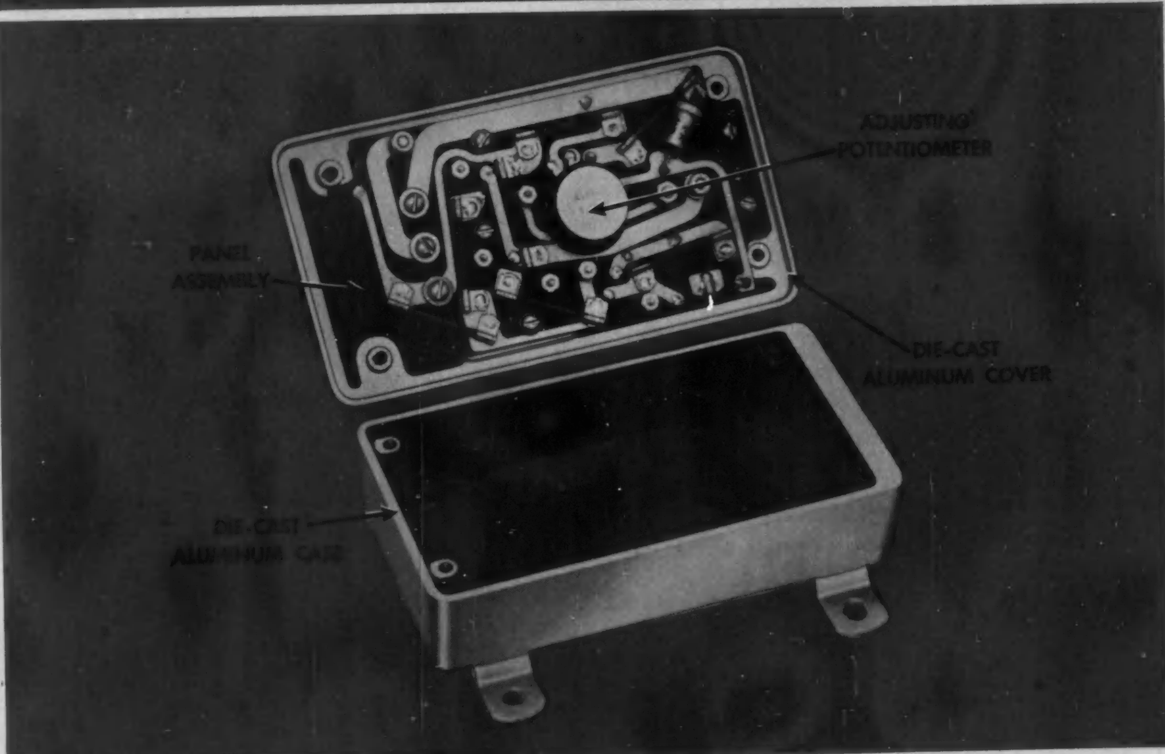
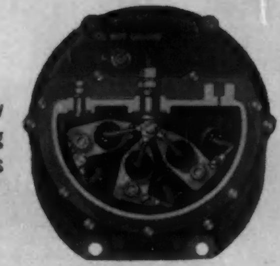
PROGRESSIVE ENGINEERING MAKES THE DIFFERENCE





TWO NEW FIRSTS FROM DELCO-REMY



End view showing rectifiers

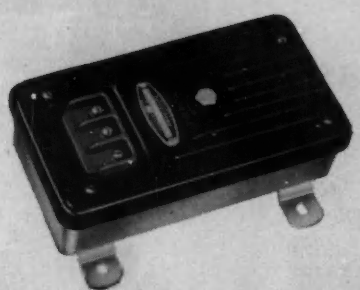
OIL-COOLED A.C. GENERATOR WITH BUILT-IN RECTIFIERS

Now, a unique new a.c. generator with integral rectifiers *requires no periodic servicing!*

Developed by Delco-Remy engineers, in cooperation with GMC Truck and Coach engineers, this radically new generator is capable of a continuous output of 215 amperes at cruising speeds and 135 amperes at normal engine idle . . . performance ideally suited to modern coaches. It is a totally enclosed, brushless unit complete with compact, built-in, long-life silicon rectifiers. All mating structural parts are sealed with special high-temperature "O" rings. *The entire assembly is effectively cooled by a continuous flow of engine oil passing through the generator.*

Sealed construction of the new unit keeps out dust and dirt and prevents damage caused by detergents used in engine cleaning. Absence of brushes, slip rings, rubbing seals and air filters, *plus* a continuous supply of engine oil for bearing lubrication, eliminates the need for servicing between engine overhauls.

This revolutionary new oil-cooled a.c. generator with built-in rectifiers is an outstanding example of Delco-Remy engineering leadership in the automotive electrical field.



External view

ALL-NEW TRANSISTOR VOLTAGE REGULATOR

Delco-Remy's all-new transistor generator regulator represents a bold new concept in voltage regulation—an electronic unit composed of durable, long-lasting transistors and diodes *with no moving parts.*

This compact new regulator performs its function electrically rather than through electro-mechanical components. By using semi-conductors as voltage-sensitive and control devices it provides more accurate control of generator voltage, and handles much higher field current for better generator performance.

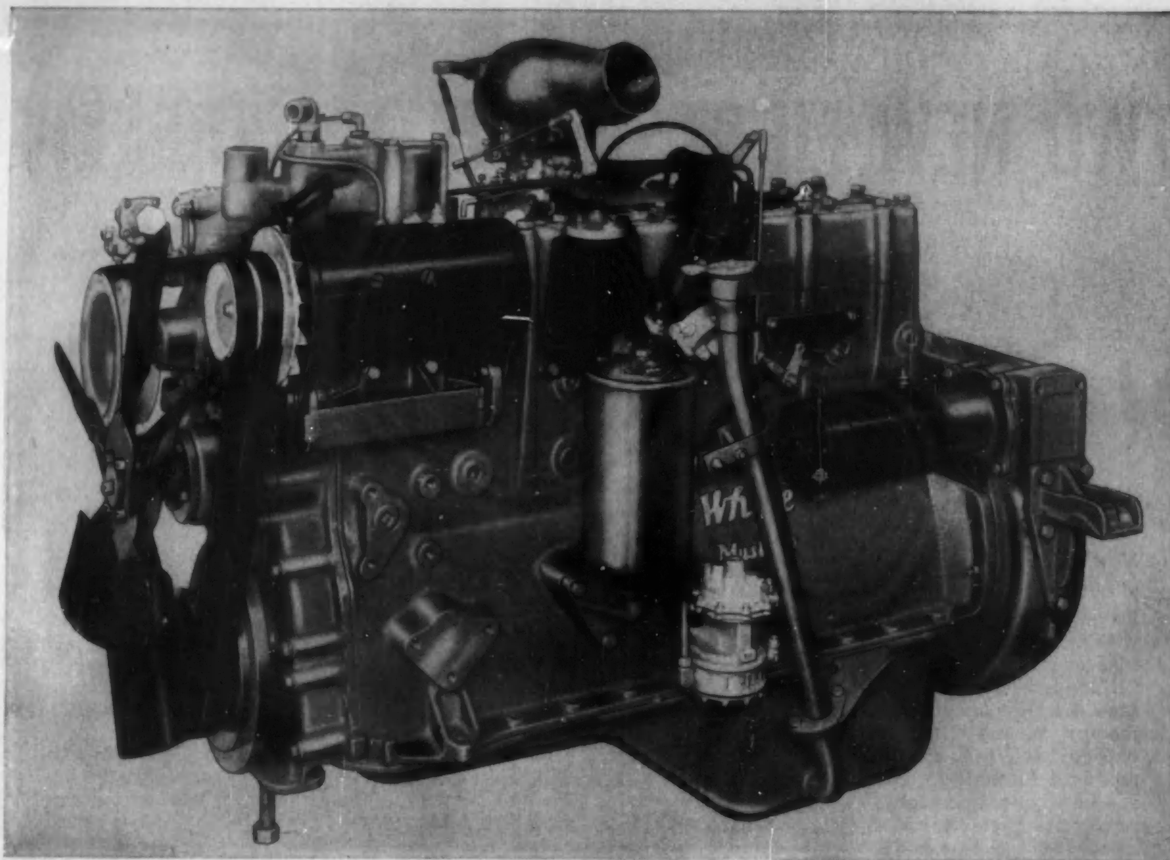
Since there are no moving mechanical parts, there are no springs, hinges, or contacts to maintain. Mounting position and vibration have no effect on its operation, and the adverse effects of temperature changes and humidity are practically eliminated. To the user this means long-lasting settings and the elimination of periodic maintenance.

This advanced design transistor voltage regulator is still another example of Delco-Remy progressive engineering at work for you.

GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY—STARTING WITH **Delco-Remy** ELECTRICAL SYSTEMS

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA



The 400-Mustangs drive White's 3000, 4000, and 9000 series tractors. In these vehicles they are giving outstanding operating economy . . . due in part to White's use of Nickel cast iron blocks.

Newest White Mustang!

Extra strength of Nickel cast iron gives her extra "go"

This is a powerful, rugged engine . . . built for maximum "go" with minimum maintenance in day-in, day-out tractor trailer service.

White Motor Company builds it. It's one of their new 400-Mustangs (145, 160, 200, 215 HP). As in earlier Mustangs, blocks for the long-lasting 400s are made of a Nickel cast iron.

Nickel cast iron meets 4 design needs

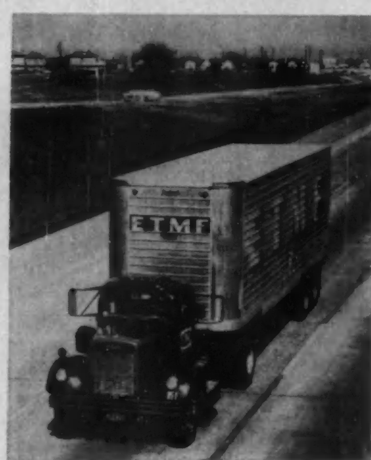
White's traditional reliance on Nickel cast iron blocks for the Mustangs is soundly based on four design needs.

Extra strength Nickel cast iron gives the light, "pillar—type" Mustang block the extra strength needed for long, reliable heavy-duty service.

Pressure tightness With Nickel cast iron the complex block can be reliably cast with the pressure tightness needed in these high compression engines.

Extra wear resistance Nickel cast iron provides the improved wear resistance for this powerful engine.

Machinability Nickel cast iron gives White fast, easy machining. Its high strength is not obtained at a sacrifice in machinability and production costs are held down.



From the fleet operator's view point . . . The light weight Nickel cast iron blocks in the Mustang improve operating economy, reduce maintenance and replacement costs, cut road side repairs.

If you buy or build internal combustion engines, look into the advantages of Nickel iron castings . . . for blocks, heads, flywheels, crank cases, camshafts, manifolds and other parts. Write for Inco's helpful "Guide to the Selection of Engineering Irons."

THE INTERNATIONAL NICKEL COMPANY, INC.
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INCO TRADE MARK

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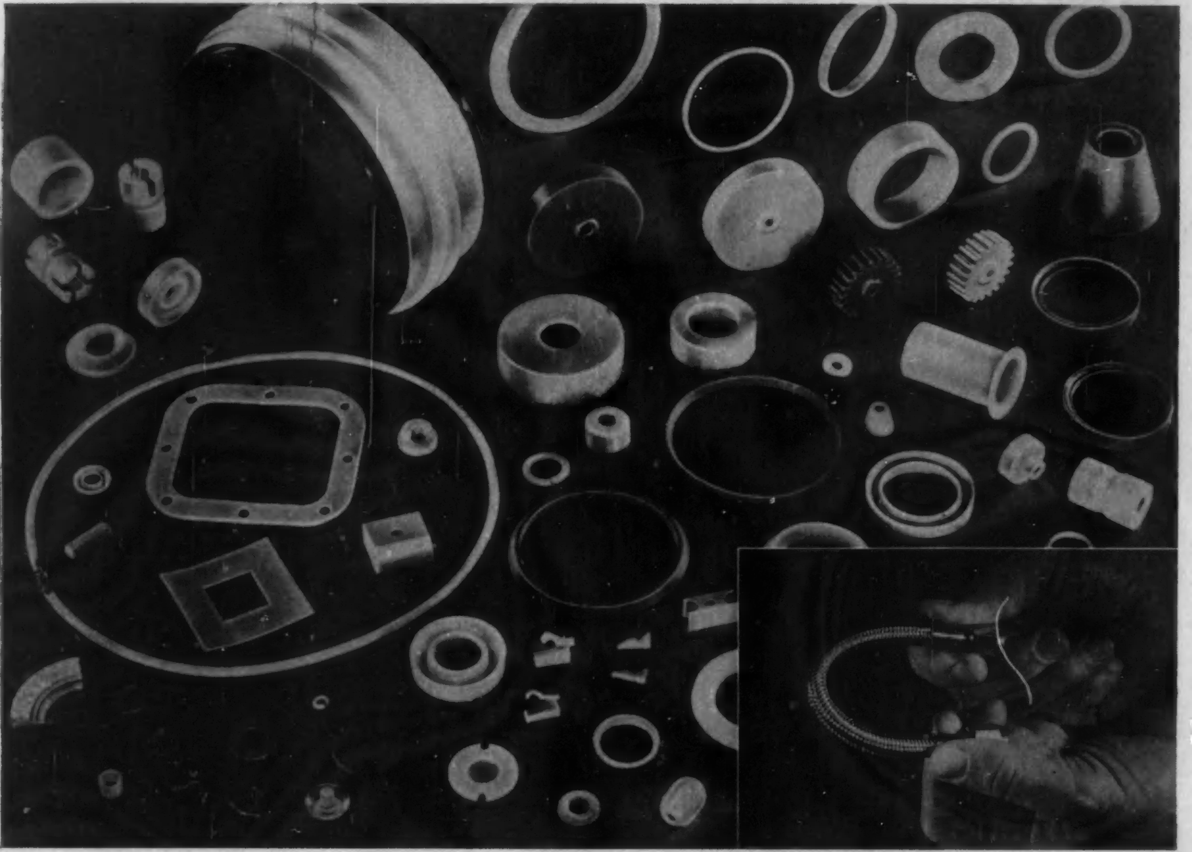
Bring R/M's greater experience, better facilities, to bear upon all your TEFLON* problems

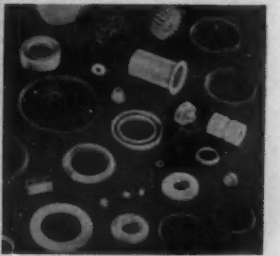


There is no substitute for the years of experience which Raybestos-Manhattan engineers have had in handling "Teflon"—nor for the unequaled plant facilities which implement this know-how. That is why we suggest that you come to R/M for *all* your "Teflon" needs.

The extruding, molding, machining, and bonding of "Teflon" is an old story at R/M. We are familiar with applications in the automotive and aircraft industries, where "Teflon" serves better than any other material, and we will be glad to fabricate parts and components to your precise specifications.

In addition, we can supply you with the other R/M "Teflon" products, such as flexible "Teflon" wire braid covered hose, "Teflon" sheets, tape, tubes, rods, and bondable "Teflon." Get in touch with your nearest R/M district office for the "Teflon" products you require and engineering information. Or write us for further information and literature.

*A Du Pont trademark



Other R/M "Teflon" products useful to your industry include centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; parts painstakingly machined to your specifications. Our mechanical grade of "Teflon"—Raylon—has many characteristics of virgin "Teflon."

R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

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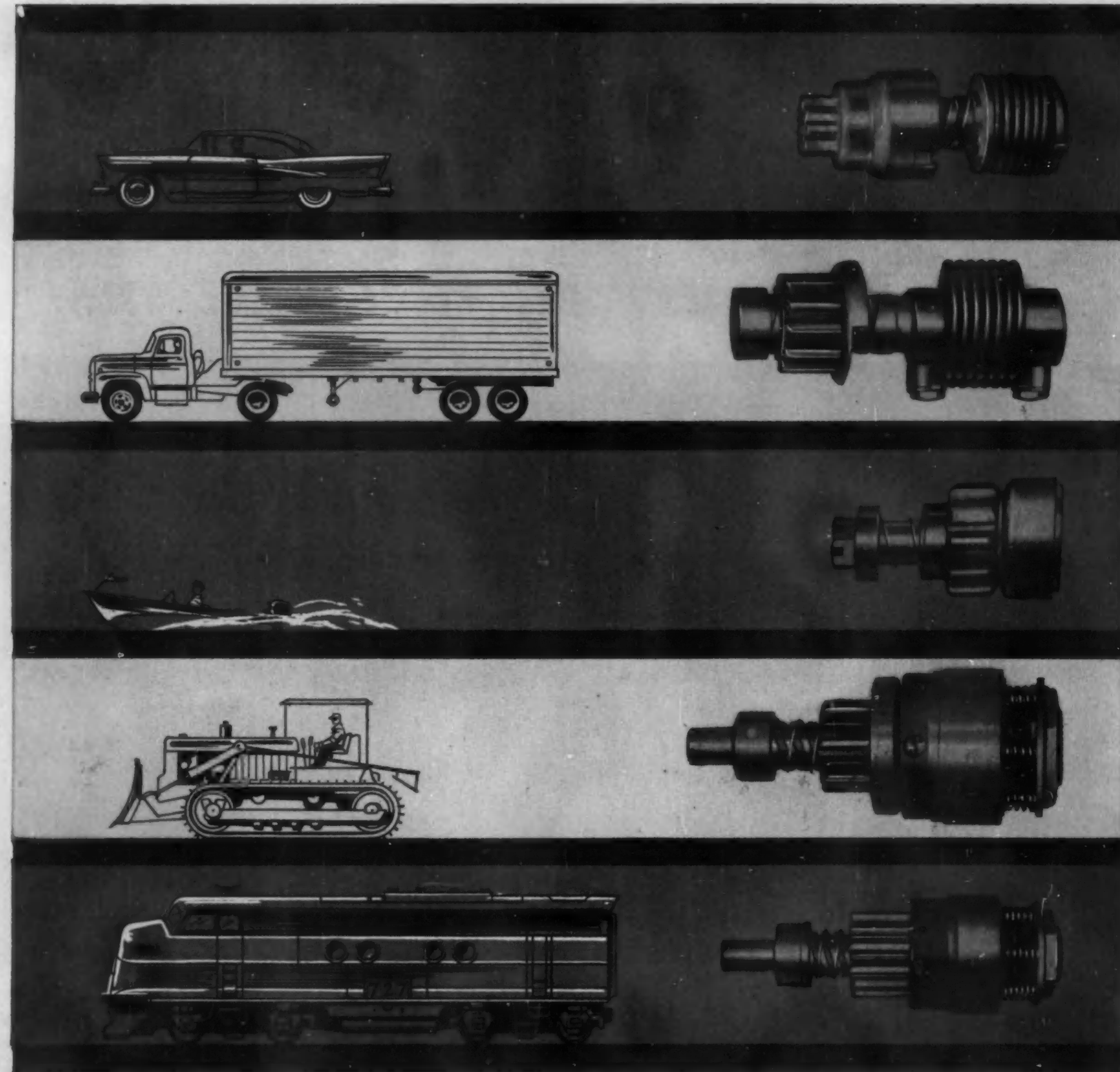

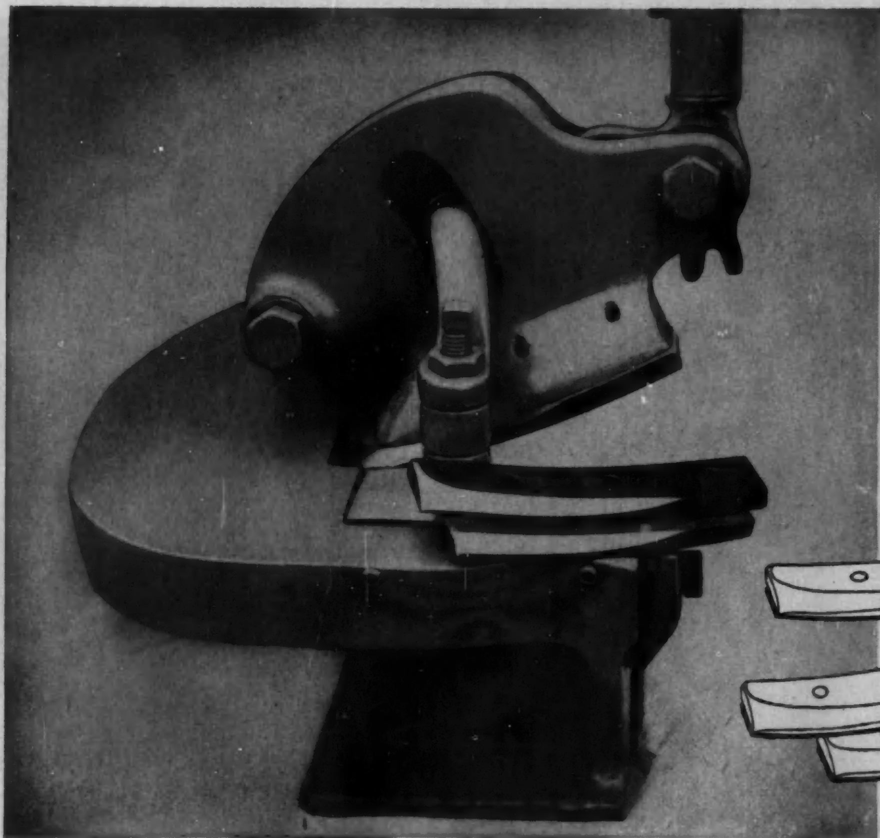

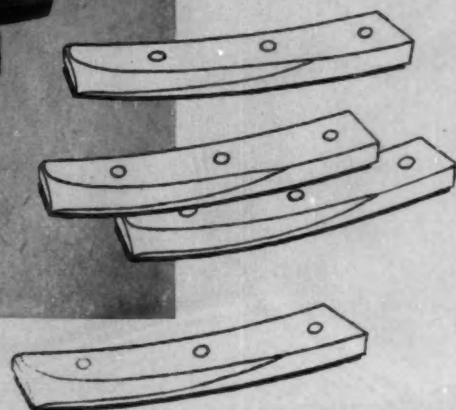

Enjay Butyl is used in the new Willys 'Jeep' FC-150 Truck—as weather strips, transmission mountings, small extrusions for doors.

ENJAY BUTYL

Improves performance, cuts costs in new 'Jeep'

The new Willys 'Jeep' "Forward Control" Truck features all-direction visibility. The more than 2,700 square inches of glass demanded a window-sealing material that would *stay* firm and weather-tight for the life of the truck. Supplier B. F. Goodrich Co. chose Enjay Butyl for weather-stripping because of its exceptional resistance to weather and aging. A tighter, longer-lasting seal is assured by the well-known vibration and shock-absorption qualities of Butyl—an important factor in this rugged-duty 'Jeep.'

Butyl offers improved quality at low cost. More and more automotive manufacturers are switching to Butyl. Today over 100 automotive parts are made with this modern rubber. For further information and expert technical assistance, write or wire the Enjay Company.

ENJAY

BUTYL

Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

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LOAD-LEVELERS
Gives Automatic Car Leveling
for all roads and loads... Calibrated to give smooth level ride, loaded, overload or light... for cars, station wagons and light trucks.
MONRO-MATIC SHOCK ABSORBERS—Standard on more makes of cars than any other brand.
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DIRECT ACTION POWER STEERING—The only truly direct-action Power Steering units available.
MONROE SWAY BARS—Specified as standard equipment on 15 makes of passenger cars.
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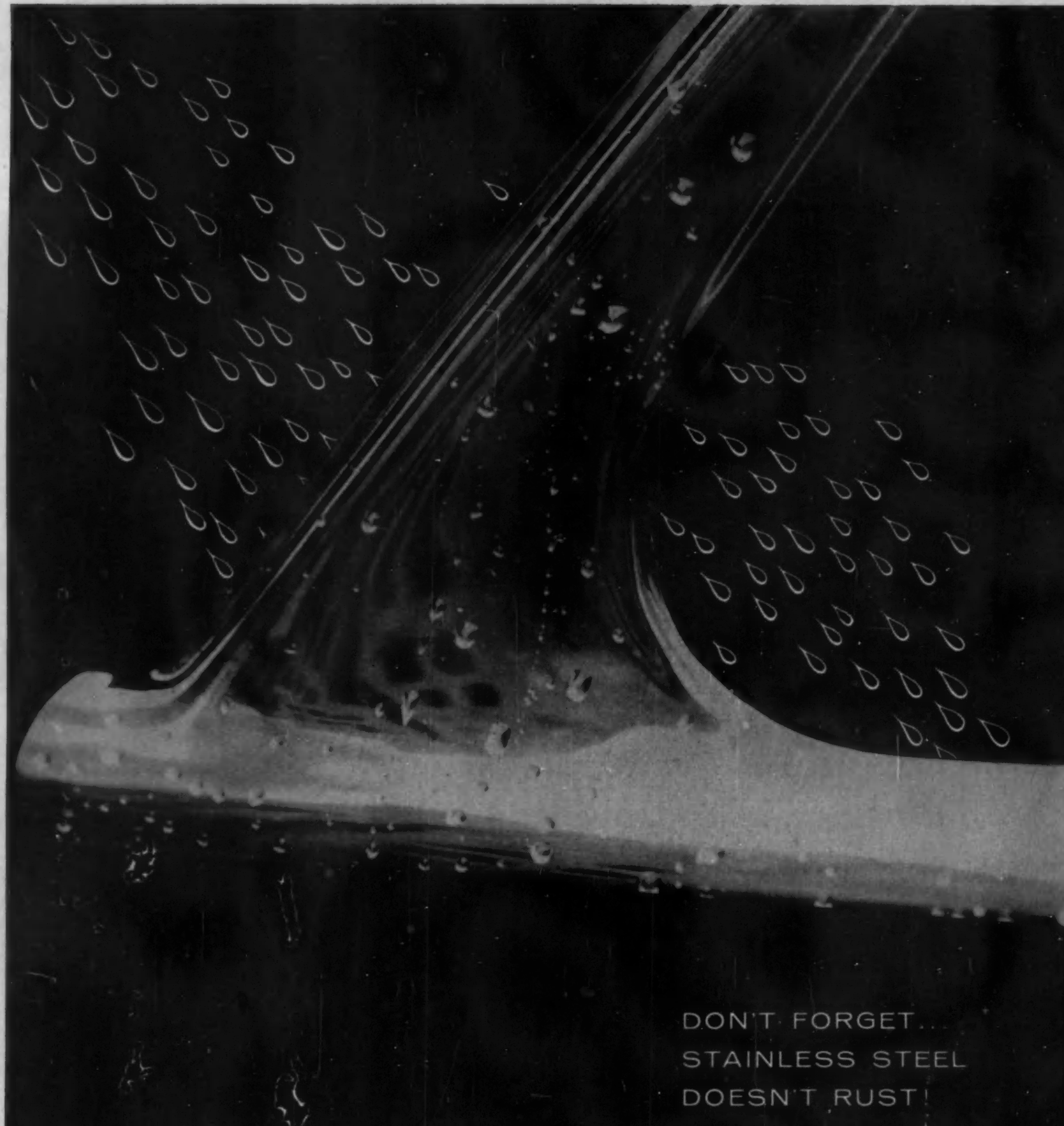
MOLDED RUBBER PRODUCTS—Precision-built for all automotive and industrial applications.
MONROE AUTO EQUIPMENT COMPANY
Monroe, Michigan—World's Largest Maker of Ride Control Products
In Canada • Monroe-Acme, Ltd., Toronto



Yes—everybody knows that. Yet it's still good to remember when you're thinking of auto trim and parts. For it's a basic reason why over 50% of all America's new car buyers prefer stainless! Car buyers know, too, that stainless helps cars bring more in resale, because stainless doesn't dent like other metals, resists scratches and road chemicals, and comes up bright as new with simple soap-and-water washing! So remember stainless—it adds so much, at so little cost. And remember, too, the best stainless steels are made with Vancoram Ferro Alloys! Vanadium Corporation of America, 420 Lexington Avenue, New York 17, New York.

Producers of alloys, metals and chemicals

VANCORAM

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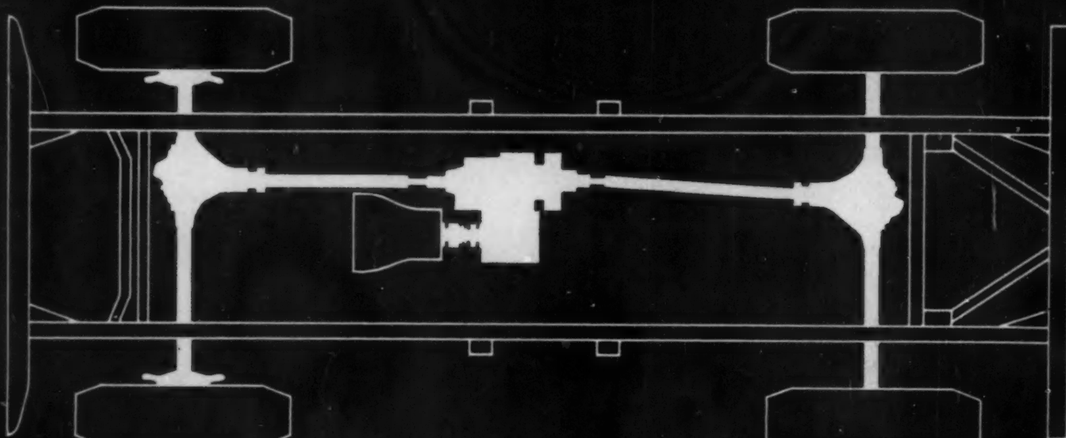
Specify SPICER
Four-Wheel Drives...
for full-power traction
AI-017

Spicer is your best source for complete Four-Wheel Drive Assemblies . . .



It's power-matched . . . and, that's the big advantage of the Spicer four-wheel drive assembly. For only Spicer can offer you front and rear driving axles, transfer cases and propeller shafts that were designed to work together.

And, you're assured of durability and quality by Spicer's record of producing 90% of the light-weight four-wheel drives in use throughout the world.

For further information, or assistance in laying out a complete four-wheel drive package, call the Dana engineers.

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DANA PRODUCTS *Serve Many Fields:*

AUTOMOTIVE: Transmissions, Universal Joints, Propeller Shafts, Axles, Powr-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

INDUSTRIAL VEHICLES AND EQUIPMENT: Transmissions, Universal Joints, Propeller Shafts, Axles, Gear Boxes, Clutches, Forgings, Stampings.

AVIATION: Universal Joints, Propeller Shafts, Axles, Gears, Forgings, Stampings.

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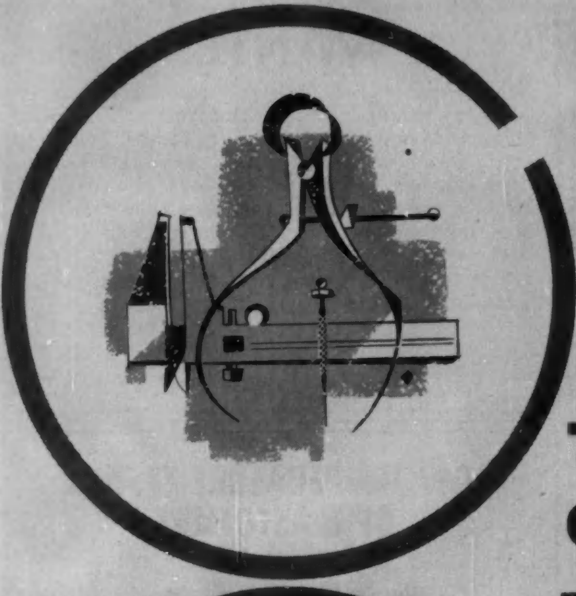
AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

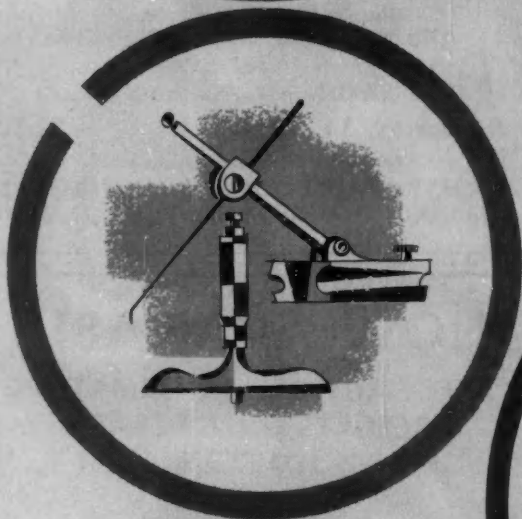
Many of these products manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

DANA
Spicer



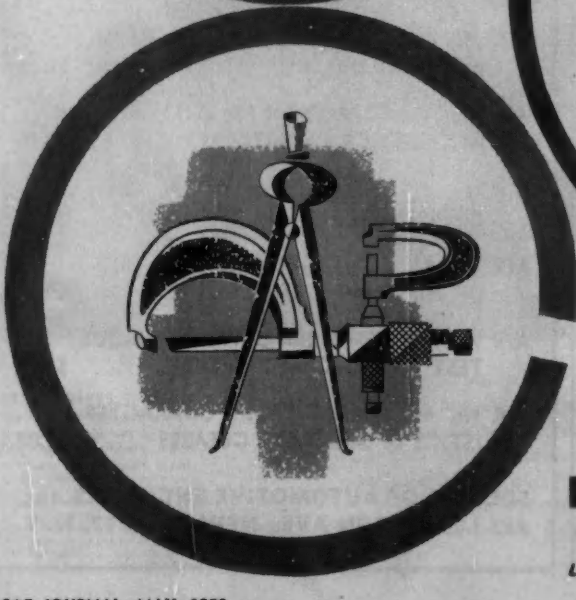
TIME TESTED QUALITY...

Piston Rings and Sealing Rings



Quality is the heart of modern production. That's why McQuay-Norris products are precision designed and manufactured to completely fulfill your specifications. We aim to give you a better product at a competitive price!

For quality that always measures up to your needs, contact McQuay-Norris.



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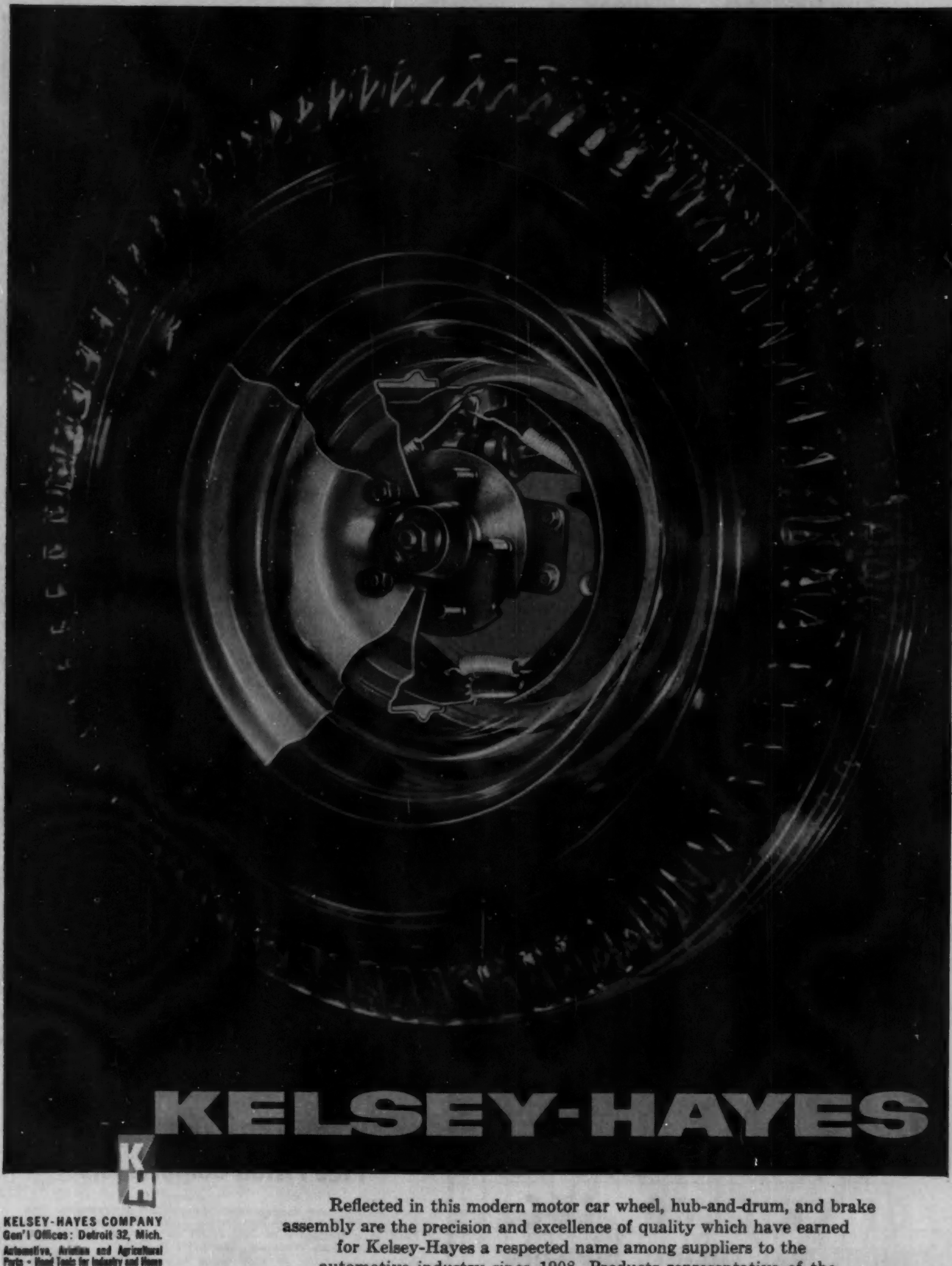
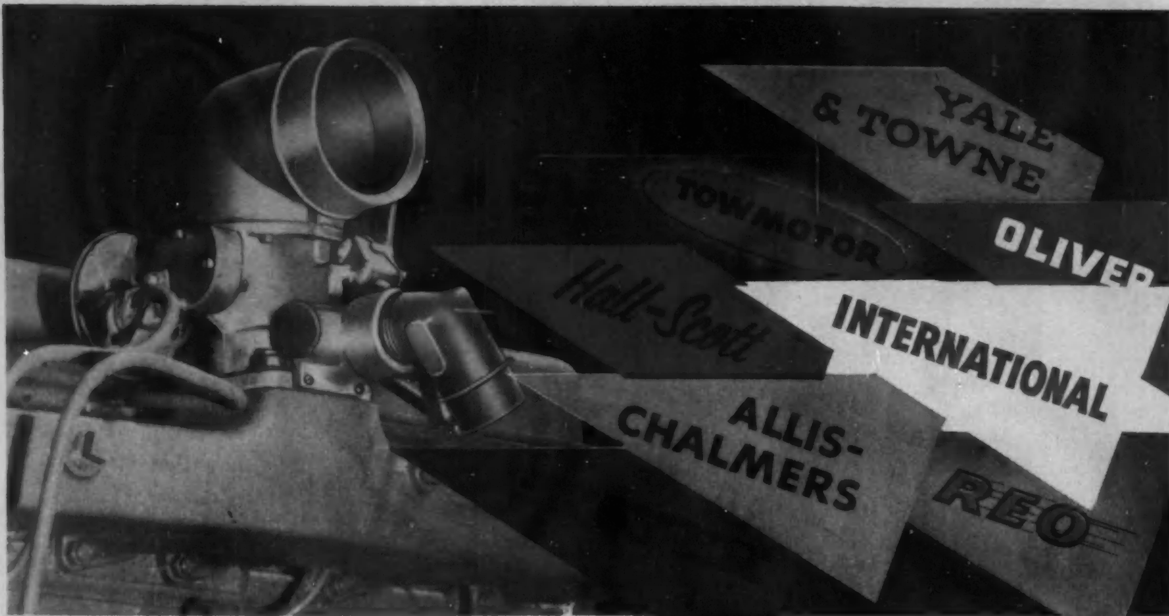
MANUFACTURING CO. **St. Louis · Toronto**

Largest Producer of Small Rings in the Automotive Industry



KELSEY-HAYES COMPANY
Gen'l Offices: Detroit 32, Mich.
Automotive, Aviation and Agricultural Parts • Hand Tools for Industry and Home
17 Plants: Detroit and Jackson, Mich.; Los Angeles; McKeesport, Pa.; Springfield, Ohio (Speco Division); Utica, N. Y. (Utica Drop Forge & Tool Division); Davenport, Iowa (Farm Implement and Wheel Division); Philadelphia, Pa. (Heintz Division); Windsor, Ont., Canada.

Reflected in this modern motor car wheel, hub-and-drum, and brake assembly are the precision and excellence of quality which have earned for Kelsey-Hayes a respected name among suppliers to the automotive industry since 1908. Products representative of the specialized skills and facilities of Kelsey-Hayes in the manufacture of fine automotive parts and components include: *wheels, brakes, hubs and drums, power brakes, transmission bands and other chassis parts.*



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who specify Century-Marvel-Schebler as factory equipment on LP-Gas models!

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All of these leaders in automotive manufacturing are factory installing Century or Marvel-Schebler carburetors on LP-Gas models.

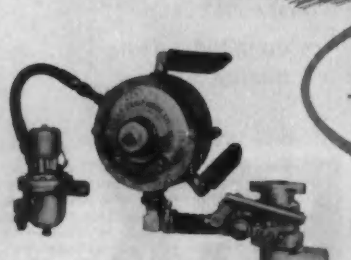
This acceptance by manufacturers is your guarantee of dependable engine performance—easy starting, perfect idling and full power for your engines.

Century-Marvel-Schebler have the most complete research and development facilities and the broadest line of LP-Gas carburetion systems ever offered. Sizes and models range from 5 to 500 h.p.

For complete information write today! Factory trained consultants are available to assist you.

3C Controlled Combustion Carburetion

Demand the dependability of a complete Century carburetion system with metering valve control of combustion.



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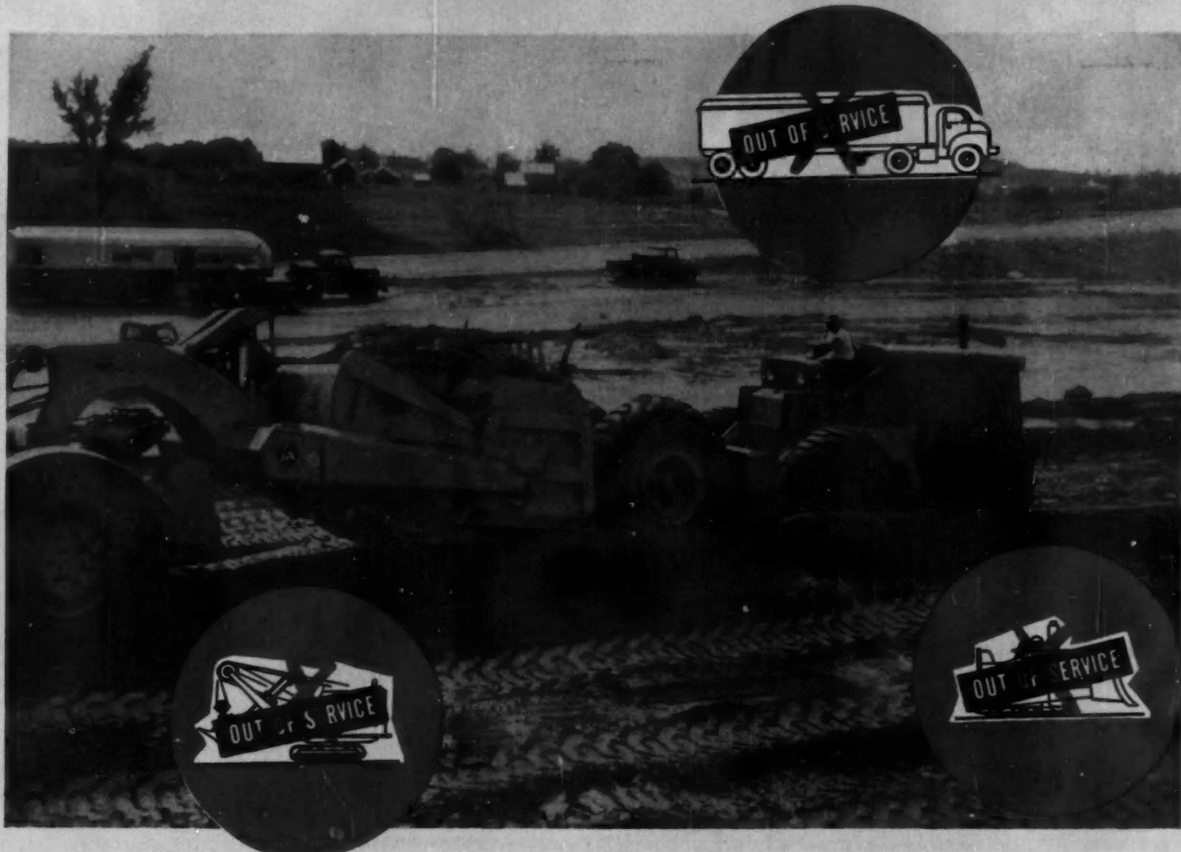
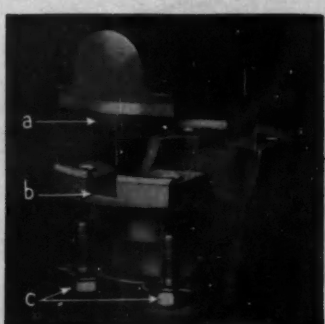
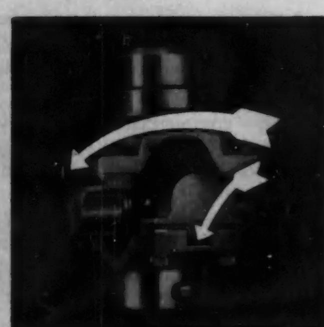
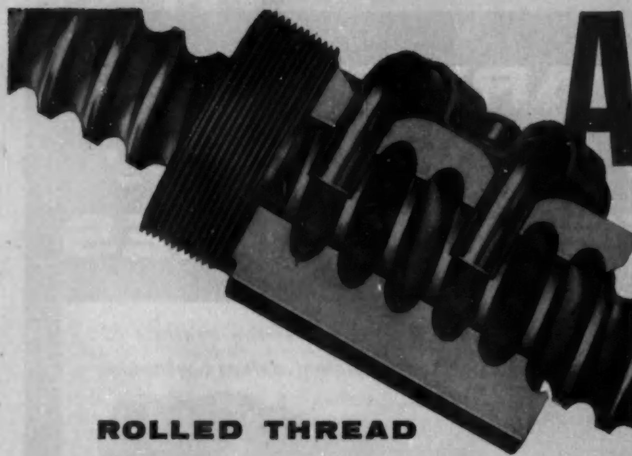
Stays OUT of the Shop









ACTUATE

MORE EASILY . . .
EFFICIENTLY . . .
ECONOMICALLY

ROLLED THREAD

SAGINAW b/b SCREWS

Make Your Product

- → **easier to produce**
- → **easier to operate**
- → **easier to sell**

The secret lies in a new anti-friction principle—steel balls recirculating in closed-circuit raceways. They permit Saginaw b/b Screws to change rotary motion into linear motion with over 90% efficiency and 4/5 less torque than Acme screws. Result: Saginaw b/b Screws save manual effort or electrical power; they permit space savings—smaller motors and gear boxes; they provide more dependable performance; more precise positioning; more temperature tolerance and more lubrication latitude.

SEVEN STANDARD SIZES REDUCE COSTS

Top-quality Saginaw b/b Screws are the only kind stocked in seven standard commercial rolled thread sizes, cut to desired length, for low cost and fast delivery. Or you can order custom machined screws for critical or extreme precision applications. Saginaw has successfully built screws from 1½ inches to 39½ feet long—⅜ inches to 10 inches diameter.

MANY TYPICAL APPLICATIONS

Saginaw b/b Screws have been applied to automatic garage doors, automobile seat adjusters and window lifts, barber chairs, hospital beds, bumper jacks and circuit breakers. Or they can be used for heavy industry equipment like die table positioners, drill presses, lift trucks and welders.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION

Let Saginaw's experienced engineers help solve your special application problems. Just write or phone us—no obligation.

Saginaw
ROLLED THREAD
ball/bearing Screw

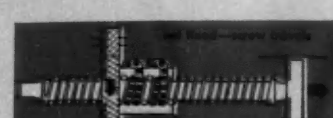
SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

Automatic Garage Door lifts and lowers easily and smoothly when actuated by Saginaw b/b Rolled Thread Screw.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS

When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



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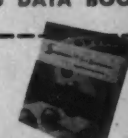
Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 5SAE, Saginaw, Michigan



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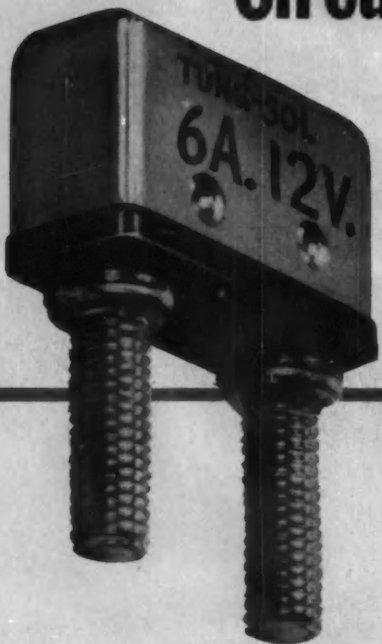
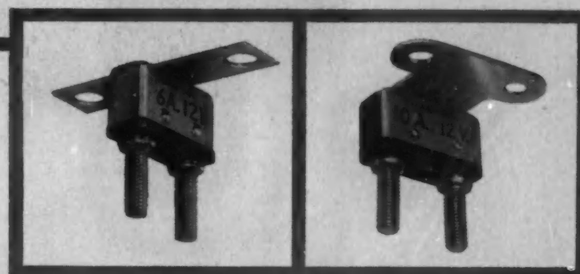
INDEX TO ADVERTISERS

Tung-Sol 12-Volt Remote-Reset Circuit Breakers



Positive "Lock Open" Action gives complete protection against:

BURNED-OUT ACCESSORY MOTORS AND WIRING
PERMANENT BREAKER DAMAGE
RUN-DOWN BATTERIES



Standard Mounting Brackets

The Tung-Sol remote-reset type circuit breakers *lock open*, instead of continuing to pulsate, when the circuit is overloaded or shorted. When the cause of the overload or short is removed, the breaker is then remotely reset. It reactivates the circuit within 30 seconds.

Available in 6, 10, 15, 20, 30 and 40 amp. ratings, in a choice of two mounting brackets, Tung-Sol Remote-Reset Circuit Breakers are used in a wide variety of automotive applications. For further information write Engineering Department.

METHOD OF OPERATION

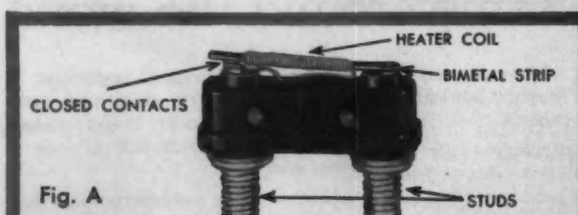


Fig. A

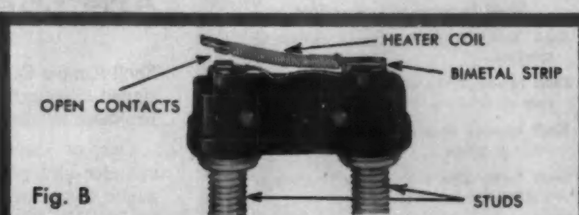


Fig. B

NORMAL CONDITIONS

When circuit conditions are normal, the current flows thru the strip which is attached across breaker studs. When contacts are closed, the heater coil is short circuited and has no heating effect. (Fig. A).

EMERGENCY CONDITIONS

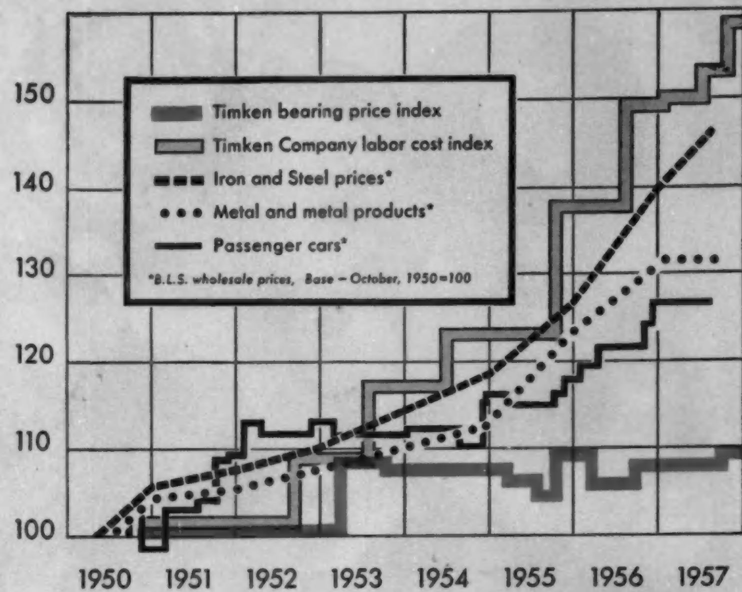
When a short circuit or overload occurs, the increased current causes strip to bend away from contacts. (Fig. B). When the contacts part, the coil is automatically inserted in the circuit.

ELECTROSWITCH DIVISION TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

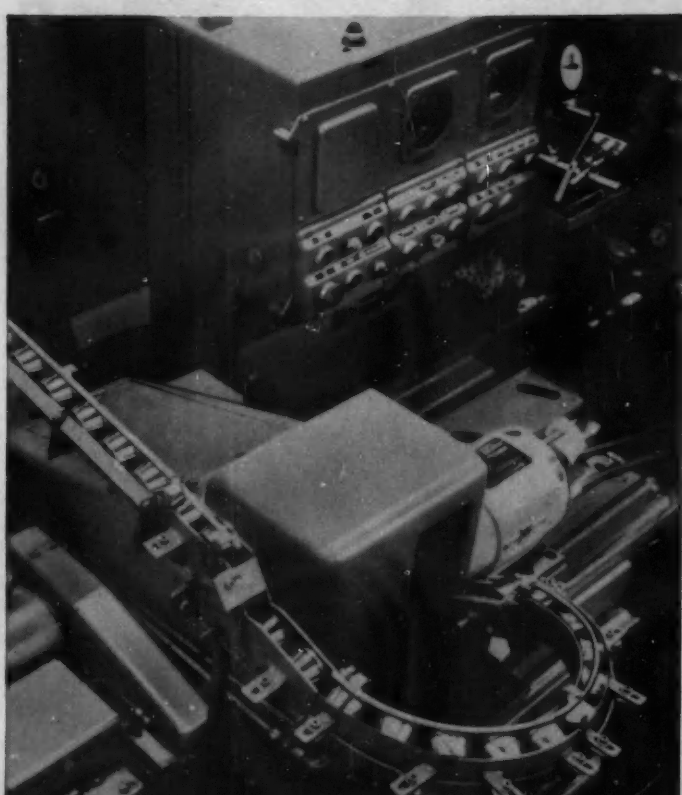
SALES OFFICES: ATLANTA, GA.; COLUMBUS, OHIO; CULVER CITY, CALIF.; DALLAS, TEXAS; DENVER, COLO.; DETROIT, MICH.; IRVINGTON, N. J.; MELROSE PARK, ILL.; NEWARK, N. J.; PHILADELPHIA, PA.; SEATTLE, WASH. CANADA: MONTREAL, P. Q.

What's way up? Everything but Timken® bearings

Chart the cost of most anything over recent years and it looks like a flight of stairs (see right). But the cost of Timken® tapered roller bearings for the automotive industry has held the line. The auto industry has helped us beat inflation by standardizing on the new Timken bearing sizes produced by revolutionary new techniques that have all industry buzzing.



TOTAL VEHICLE COST OF PINION, DIFFERENTIAL, REAR WHEEL AND FRONT WHEEL BEARINGS



Here's how to keep 'em way down

Here's the inside of our unique Bucyrus, Ohio, plant where custom-made machines turn out 30 million new design Timken bearings a year without a hand touching them. This plant can keep your bearing costs down if you: 1) standardize on even fewer Timken bearing sizes—lowering our production costs, increasing your savings; and 2) buy more Timken bearings—the bearings made by low-cost missile age techniques. The more you put standardization to work, the better we can keep your bearing costs down. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

BEAT INFLATION WITH... STANDARDIZATION

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TAPERED ROLLER BEARINGS